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WATER POLLUTION RESEARCH

TECHNICAL PAPER NO. 2

SURVEY OF THE RIVER TEES

Part I.—Hydrographical

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Parts of Sheets 3, 6, 7.

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Scale of ½ Inch to One Mile. 126720

2 1½ 1 ½ 0 2 4 6 8 Miles

Ordnance Survey 1931.

The Altitudes and Contours are given in Feet above Ordnance Survey Datum, (Mean Sea Level)

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PREFACE

DURING recent years there has been a growing appreciation of the need for research bearing on the application of practicable methods and the scientific development of new methods of avoiding or minimising the pollution of the rivers and other water supplies of the country by industrial effluents and sewage. To meet this need the Water Pollution Research Board was set up in June, 1927, for the purpose of submitting schemes for research on the various problems involved and supervising the conduct of approved investigations.

The subject of water pollution has become more important with the growth of the population and the development of industry. The growth of the population increases the work of disposal of sewage and improved sanitation is throwing a greater burden on the water supplies, the purity of which is a most important factor affecting the health of the community. In addition to the requirements for domestic purposes, water of good quality and in large quantities is also necessary for many industrial processes, and it seems inevitable that, in the future, rivers will have to be used to an increasing extent as sources of supply.

One of the first conclusions reached by the Water Pollution Research Board was that reliable information was urgently required as to the effects on rivers of various polluting discharges, and the Board recommended that a comprehensive scientific survey of a typical river flowing through an industrial area should be undertaken. It is known that rivers which have received polluting liquids are capable of self-purification under certain conditions but there is a lack of exact knowledge of those conditions and of the quantities of various effluents which can be allowed to enter a river without unduly retarding the processes of self-purification.

After full consideration it was decided that the River Tees afforded the main characteristics desirable in a pioneer investigation of this kind. Further, the work that had previously been carried out on the Tees, although insufficient to provide answers to the questions involved, was sufficient to enable a programme of research to be fairly clearly mapped out. Preliminary inquiries had also indicated that local interests would be willing to afford facilities and to co-operate in any Consultative Committee set up.

A River Tees Survey Committee of the Water Pollution Research Board was accordingly appointed to draw up a detailed programme of investigation and to supervise the work, and on the recommendation of the Board the Department of Scientific and Industrial Research also set up a River Tees Survey Consultative Committee representative of the various local interests, for the purpose of ensuring effective consultation with those who had offered their co-operation.

The work of the survey, which was commenced in April, 1929, has been divided into two main sections, comprising the tidal and non-tidal reaches respectively, and the work on the tidal reach has been further sub-divided into two sections, the one to secure hydrographical data and the other to obtain biological and chemical information. In connexion with the survey of the non-tidal reach, which is being carried out for the Department by the Ministry of Agriculture and Fisheries, a fixed laboratory has been equipped at Barnard Castle and a travelling laboratory is being used for those observations which must be made on the spot and without delay. The biological and chemical surveys of the tidal reach are being carried out for the Department by the Marine Biological Association of the United Kingdom and for this part of the work a laboratory has been equipped at the Cleveland Shipbuilding Company's Yard, Middlesbrough, where accommodation has been obtained through the kindness of the Hon. Sir Charles A. Parsons and Messrs. The Parsons Marine Steam Turbine Company, Ltd. For the hydrographical work a hydrographical surveyor was appointed and the work has been carried out in close co-operation with Rear-Admiral Douglas, C.B., C.M.G., Hydrographer of the Navy. Arrangements have also been made with the Meteorological Office of the Air Ministry to furnish data of the rainfall in the watershed of the Tees throughout the period of the survey.

The biological and chemical surveys are likely to occupy about three years, but the agreed programme of the hydrographical work has now been completed. Additional information regarding current flows will be obtained from the systematic observations of salinities now being continued in different parts of the estuary. Since, however, the more direct measurements of flow in the tidal section have been completed, it is considered that the results of these measurements should immediately be made generally available and publication not delayed until the biological and chemical work has reached a more advanced stage.

When the hydrographical survey was commenced little was known of the regime of the estuary beyond what was necessary for the safety of navigation. The rise and fall of the tide, the times of high water and low water, and the strength and direction of the surface tidal stream had been carefully determined by the Tees Conservancy Commission, and there was a certain amount of local knowledge of the effect of a spate on the movements of the water in the lower reaches. The limits of tidal movement were known and also the fact that the water became gradually fresher as one proceeded up stream; while it was obvious that the escape of polluting matter to the sea was delayed by tidal movement. It would, however, have been impossible to answer, except by a guess, a question as to what took place below the surface. Did the tide change at the same moment at all depths; did the tidal stream run at the same speed at the surface and on the bottom; and, if there was a difference, was it a gradual one or was the water divided sharply into layers of different character? It would have been possible to suggest, on the analogy of what has been observed in Scandinavian rivers, that there existed differences between surface and bottom layers, but this could not have been stated with certainty. The programme for the hydrographical survey was, therefore, drawn up in partial ignorance, and if the work were to be planned again in the light of present knowledge, the programme would be extended in some directions and probably restricted in others. Not the least important function of the survey has been to show how such investigations should be conducted, and it is hoped that this investigation may serve as a model for surveys of other estuaries.

The hydrographical observations recorded in this report were made by Lieut.-Commander J. F. Denman, R.N.; Lieut.-Commander R. M. Southern, R. N., and Mr. D. J. Matthews, F.I.C., assisted in the production of the report, which, with the diagrams, was prepared in the Hydrographic Department of the Admiralty. Valuable advice on the arrangement of the report was given by Mr. F. O. Stanford, M.Inst.C.E., of the Engineering Department of the Ministry of Health.

In addition to the acknowledgments already made, the Department wishes to express appreciation of the valuable assistance rendered by the Tees Conservancy Commission, their General Manager, Mr. J. H. Amos, their Engineer, Mr. P. A. R. Leith, and their Harbour Master and staff, who aided the work by allowing the use of various records and data in their possession, and on several occasions provided men and boats to assist in carrying out the work; by the Tees Valley Water Board and their Engineer, Mr. G. R. Collinson, M.Inst.C.E., who assisted in some of the observations; the Durham County Council and their Surveyor, who gave permission for a gauge to be erected at Croft Bridge; Mr. R. H. Humphrey, of Hurworth, and Major R. O. Squarey, of Middleton-One-Row, who kindly allowed the banks of the river at Middleton to be used during certain observations made there; and by Mr. R. Stevenson, who is in charge of the Cleveland Shipbuilding Company's Yard.

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Director of Water Pollution Research.

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April, 1931.

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SURVEY OF THE RIVER TEES

Part I—Hydrographical

OBJECTIVES OF THE HYDROGRAPHICAL SURVEY

AS explained in the preface to this report, the Water Pollution Research Board came to the conclusion that reliable information is urgently required as to the effects on rivers of various polluting discharges. Rivers which have received polluting effluents are capable of self-purification under certain conditions, but there is a lack of precise information regarding those conditions, including the quantities of different effluents which may be admitted to a river without causing serious pollution. On the Board's recommendation, the Department arranged for a comprehensive scientific survey of a typical river flowing through an industrial area, and the River Tees was chosen as presenting the main characteristics desirable. An investigation of this kind must include a study of the biological and chemical changes which occur in the river and the effects produced by various effluents. The interpretation of the results of the biological and chemical work, which is still in progress, involves a knowledge of the flow of the fresh water of the upper river and of the movements of the fresh and the saline water in the estuary. The investigation was planned, therefore, to include hydrographical observations, particularly in the estuary. The direct measurements of flow have been completed and the methods of measurement adopted and the results obtained are described in this report.

The principal objects of the hydrographical survey were to obtain detailed information on the tidal movements in the river and estuary of the Tees with special reference to the following points :—

1. Strengths of the currents and the volumes of water moving up and down the river at different times and places over all ranges of the tide and at all depths.
2. The general movement of the water between Stockton and the sea.
3. The effect of fresh water floods on tidal movements in the estuary.
4. Comparisons of water level at different states of the tide.
5. Times and heights of High and Low Water throughout the estuary.

GENERAL DESCRIPTION OF THE RIVER

The Tees rises on the slopes of Cross Fell and pursues a fairly straight course for about 54 miles as far as Croft Bridge, which is approximately 42 miles by river from South Gare Lighthouse at Tees Mouth. From Croft Bridge it follows a winding course as far as Middlesbrough, where it opens out into a broad estuary, and reaches the sea 6 miles further on. Several tributaries enter the river at various points, and of those which join the main stream below the tidal limit the Leven is the most important. The tidal limit, i.e., the highest point up the river where tidal influences are felt, is near the village of High Worsall, a distance of about 25 miles from the mouth.

Tidal investigations were confined to the section of the river between Stockton and the mouth, a distance of about 12 miles by river. It is this part which is mainly affected by pollution ; the untreated sewage of Thornaby, Stockton, Middlesbrough and of the growing population of Billingham is discharged into it, together with the effluents from a large number of manufactories. The tidal part of the river may be divided into three distinct sections :—

1. From the tidal limit near High Worsall Village to Victoria Bridge, Stockton, a distance of about 13 miles, the river runs between natural banks and is not dredged. It is not used by shipping.
2. From Victoria Bridge to Cargo Fleet, a distance of 7 miles, the channel is dredged and runs between natural banks and training walls.
3. The section from Cargo Fleet to the mouth, a distance of 5 miles, has the general characteristics of an estuary. In this section the dredged channel used by shipping is bounded by training walls. On the west the Seal Sands and on the east the Bran or Fourth Buoy Sands stretch out for some distance beyond the sides of the channel.

In the section from Stockton to the mouth of the river ten stations were selected at which to make a complete investigation into the movements of the water at all states of the tide. The positions of these stations are shown on Plate 1, the distances between them being given in feet.

FRESH WATER OBSERVATIONS

Movements of the water in the tidal estuary are obviously affected by variations in the flow of fresh water coming down the river. Before carrying out current and tidal observations below Stockton, it was therefore necessary to arrange for continuous observations to be made of the fresh water passing down the river at some point above the tidal limit.

For this purpose a water level gauge was erected at Croft Bridge, which is about 17 miles above the tidal limit. The river at this point is not ideal for the current observations, which were carried out over a measured distance of 100 yards just above the bridge. There is a bend in the river immediately above the measured distance, and this bend is accentuated when the water level rises, so that accurate results were at times difficult to obtain. This, however, was the best place that could be found below the junction of the River Skerne, and it possessed the advantage that a level gauge could be erected on the bridge, which is one of the few structures across the river, the columns or supports of which do not wholly dry out when the river is low.

The zero of the gauge on Croft Bridge was 84·5 feet above Ordnance Datum (Liverpool). Readings of the water level were commenced on 10th April, 1929, and continued during the whole period of observations in the tidal estuary. Readings were regularly taken twice daily—at 0745 and 1745 G.M.T. Current observations over the measured distance were taken at intervals and a cross-section of the river (Plate 2) was made near the centre of the measured distance to enable the necessary calculations of volume to be made.

The observations at Croft Bridge served a twofold purpose. They provided data for estimating the volume of fresh water entering the tidal portion of the river. They also provided information on the passage of fresh water floods down the river so that, when exceptional conditions prevailed which would vitiate the results of current observations in the tidal estuary, the work in the estuary could be temporarily suspended until the flow of fresh water again assumed normal proportions. It has not been considered necessary to include the records of the water level at Croft Bridge in this report, as these observations are still in progress.

The summer of 1929 was very dry and the river was at an exceptionally low level for long periods, on occasions falling to 3 in. on the gauge at Croft Bridge. The normal summer level was estimated to be 1 ft. on the gauge. During November and December, with heavy rainfall, the water level fluctuated considerably. On 10th November and 29th December the level rose to 16 ft. on the gauge. The alteration of level during heavy floods is very rapid. On 10th November the gauge read 15 ft. 6 in. at 0745, but at noon on the same day the level had fallen to 6 ft. On 11th December the river rose 8 ft. in 10 hours. The level appears to change more rapidly when the river is falling. On 24th October a flood passed Barnard Castle at 0400, reached Croft Bridge at 0900, and Yarm at 1415 on the same day. The highest reading recorded at Croft Bridge on this occasion was 8 ft. at 1700. The distance from Barnard Castle to Yarm by river is about 46 miles, which gives an average speed of about $4\frac{1}{2}$ miles per hour.

During the winter months the level fluctuates considerably when the gauge reads above 2 ft., but after a few fine days without much rain the level remains fairly steady at 1 ft. 9 in. This height may be taken as the normal winter level.

Local rain in Lower Teesdale does not appear to affect the height of the river appreciably. Owing to the narrow catchment area and the few tributaries, the fresh water floods can be definitely referred to heavy rain storms in Upper Teesdale. The only large tributaries draining the lowland are the Skerne and Leven, and floods in these tributaries are not heavy enough to affect the discharge of the Tees to any great extent. Above Piercebridge all the tributaries drain the hills in Upper Teesdale, and the water carried down by these tributaries adds appreciably to the discharge of the main river. In fine weather the river settles down with remarkable rapidity to the normal summer or winter level. It will, therefore, be seen that the discharge of the river is only temporarily affected by heavy rain.

CALCULATIONS OF FRESH WATER DISCHARGE

Current measurements were made with surface floats over a distance of 100 yards just above Croft Bridge, times being taken to the nearest second. In most cases three readings in the centre and three at each side were taken and the average values obtained. In all, 31 of these surface current observations were made, and the resulting volumes plotted against the height on the gauge are shown in Plate 3.

An examination of this diagram will show that the readings are fairly consistent up to a height of 2 ft. 6 in. on the gauge, and a fair curve may be drawn through the points. For levels above 2 ft. 6 in. the readings are too high, due to the effect of the bend of the river above the measured distance. This bend tended to force the floats towards the Durham side of the river, where the speed of the current is greatest. When the water level is low the bend has much less effect and the accuracy of the readings may be relied on.

The curve drawn on Plate 3 as a continuous line shows uncorrected values for the volume of discharge up to a height of 6 ft. on the gauge. This curve is plotted according to the observations up to a height of 2 ft. 6 in. on the gauge, but has then been carried on as a straight line on the assumption that this more nearly represents the true direction than a curve following the observations above this height. The latter part of the curve shown as a continuous line can only be taken as approximate for the reasons already explained.

Experiment has shown that the average speed of the current over the whole cross-section of a free-flowing river is about 0·8 times that of the average speed of the surface current. A lower curve is therefore plotted on the diagram, the volume represented by this curve being 0·8 times those obtained from the surface current observations. The estimated true volumes of fresh water passing down the river under different conditions of water level at Croft Bridge can be read off from this curve.

In order to check the accuracy of the work at Croft Bridge, observations with a current meter were made on 17th December at Middleton-One-Row, which is 15 miles by river below Croft Bridge and 2 miles above the tidal limit. The gauge at Croft Bridge was steady at 1 ft. 8 in. throughout the day. Float measurements were also made at Middleton simultaneously with the current meter measurements, in order to check the accuracy of the float method. The following results were obtained for the flow of fresh water :—

(1) 1,080 cubic yards per min., or 21·0 million cu. ft. per 12 hrs., from Croft Bridge curve, Plate 3.

(2) 963 cubic yards per min., or 18·7 million cu. ft. per 12 hrs., from current meter measurements at Middleton-One-Row ; indicated on Plate 3 by ⊕.

(3) 1,090 cubic yards per min., or 21·2 million cu. ft. per 12 hrs., from float measurements at Middleton-One-Row.

It is considered that the results derived from current meter observations are of a fairly high order of accuracy (probably an error of less than 5 per cent.), so that the float method which was used at Croft Bridge gives results that are about 10 per cent. too high. Entering the river between Croft Bridge and Middleton-One-Row there are five small streams which slightly augment the discharge of fresh water at the latter place, a further indication that the Croft Bridge curve gives high readings.

Croft Bridge and Middleton-One-Row are above the junction of the Tees and the Leven. In estimating the fresh water entering the estuary, the discharge from the Leven must also be taken into consideration. This tributary, draining from the Cleveland Hills and the low land south of the Tees, enters the tidal estuary $1\frac{1}{4}$ miles below Yarm. As it drains an entirely separate area from that drained by the Tees, it is quite possible that the Tees may be in flood when the Leven is low and *vice versa*.

During December two attempts were made to gauge the flow of the Leven over the weir at Leven Bridge. Unfortunately, on each occasion the work was prevented by the head of water on the weir. Further observations, if opportunity occurs, would be desirable at this point. In the absence of direct observations, it is necessary to make some definite assumption with regard to the additional

discharge of fresh water from the Leven and other small streams entering the river below Middleton-One-Row and the sewage of Yarm, Preston, Stockton and Thornaby. It is considered that this total discharge amounts to approximately 10 per cent. of the fresh water coming down the main river. This quantity, as it happens, just compensates for the assumed error of measurement at Croft Bridge, and the Croft Bridge curve (Plate 3) may therefore be taken as indicating the *total* discharge into the tidal estuary above Stockton bend.

From observations between April and December, 1929, it has been concluded that the average heights of water on the gauge at Croft Bridge under three typical conditions may be taken as :—

(1) Normal summer level = 1 ft.
Corresponding discharge of fresh water = 8 million cu. ft. per 12 hours, or 100 million gallons per 24 hours.

(2) Normal winter level = 1 ft. 9 in.
Corresponding discharge of fresh water = 23 million cu. ft. per 12 hours, or 287 million gallons per 24 hours.

(3) High winter level = 2 ft. 6 in.
Corresponding discharge of fresh water = 42 million cu. ft. per 12 hours, or 523 million gallons per 24 hours.

Observations have shown that under normal winter conditions the water only occasionally rises above 2 ft. 6 in. on the gauge. The heavy rains during November and December, 1929, when the river was constantly in flood, may be considered abnormal. Any higher discharge than 42 million cubic feet per 12 hours is exceptional, and it is doubtful whether any useful results can be obtained by attempting to estimate the discharge with the river in high floods which last only a few hours.

For purposes of comparison it may be mentioned that the average flow of the River Thames at Teddington Weir over a period of 35 years (1883 to 1917) ranged from about 500 million gallons per day in September to about 2,400 million gallons per day in January.

CURRENT MEASUREMENTS IN THE TIDAL ESTUARY

Upper River at Summer Level

Current measurements were made at ten stations in the river between Stockton and Tees Mouth ; the positions of these stations, lettered A to K, are shown on Plate 1. In all, observations were made on 126 days, spread over a period of seven months. The readings were made at each station by means of a current meters from boats anchored in the centre of the river, two stations being manned on each occasion. At Station F a complete series of readings was obtained, both in the centre and at the sides ; at other stations side readings were obtained when practicable. The strength of the current was measured every half hour at the surface and at 1 fathom intervals of depth ; the normal period of a reading was two minutes. River traffic interfered with the work to a certain extent, but at only one position (at 9th Buoy Light) was it necessary to discontinue observations on this account ; the observations at this station have not been included in the report.

The range of the tide in the tidal estuary at 4th Buoy varies from a maximum of 17 feet at Springs to a minimum of 5 feet at Neaps. The horizontal movements of the water in the estuary vary greatly with this change in the range, and, for convenience, the records of current observations have been divided into four groups according to the range of tide.

Range I	8 ft. and below (Neaps).
Range II	8 to 11 ft.
Range III	11 to 14 ft.
Range IV	Over 14 ft. (Springs).

The current observations at each station will now be considered *seriatim*. There are four diagrams for each station, except when a series is incomplete,

corresponding to the four ranges of tide into which the observations are grouped. The diagrams consist of :—

(1) Curves showing the strength of the current in feet per second at the surface and at 1 fathom intervals of depth compared with the interval in time before or after high water, drawn from the means of all observations obtained ; these observations vary in number from 2 to 5 at each station.

(2) Iso-pleths derived from the current curves. These give the same information in different form, and enable currents at intermediate depths to be read off conveniently.

In addition, a tabular statement of the same information for each station is given in Table 1.

Station A. Plate 4.

It was not the original intention to make current observations at Station A, but on 19th July a 12½-hour series was made on Range II in conjunction with salinity determinations.

Station B. Plates 5, 6 *and* 7.

Diagrams for Station B are given only for Ranges I, III and IV, the observations on Range II being insufficient to provide the necessary data. For the purpose of calculating the volumes of water passing this station on Range II, the observations at Station A have been used. The fastest speeds recorded were :—

Flood : 3·10 ft. per sec. at 1 fathom depth at 2 hours before high water on Range IV.

Ebb : 2·95 ft. per sec. on the surface at 4 hours after high water on Range IV.

On all ranges of tide the flood is strongest at 1 fathom depth. At high spring tides the time of low water at this position is half an hour later than at 5th Buoy Light and the time of high water is 15 minutes later than high water at 5th Buoy. It will be noticed that for Ranges III and IV the curves are not smooth ; the strength of the surface current remains steady from 4 to 3 hours before high water and from 2 to 3½ hours after high water. The curves for the sub-surface currents show the same tendency.

Station C. Plates 8, 9, 10 *and* 11.

The fastest speeds recorded at Station C were :—

Flood : 3·70 ft. per sec. at 2 fathoms depth at 2 and 2½ hours before high water on Range IV.

Ebb : 4·90 ft. per sec. on the surface at 4 hours after high water on Range IV.

The speeds of the current in all four ranges are high compared with those at most other stations owing to the narrowing of the river which occurs here. In addition, an old river bed joins the main channel on the south side about 2,500 ft. above Station C. This cut takes a large quantity of water from the channel, and combined with the narrowing of the channel, accounts for the high speeds recorded at C. On Range I the flood only flows for 4 hours on the surface and changes at 5 hours and 1 hour before high water. The maximum strength of the flood runs at the depth of 2 fathoms in each range. The " waves " in the speed curves are very marked.

Station D. Plates 12, 13, 14 *and* 15.

The highest speeds recorded at Station D were :—

Flood : 2·60 ft. per sec. at a depth of 2 fathoms at 2½ hours before high water on Range IV.

Ebb : 3·60 ft. per sec. on the surface at 4½ hours after high water on Range IV.

The weakness of the surface current on the flood compared with the sub-surface current is noticeable. The main strength of the flood runs at a depth of

2 fathoms. The " waves " in the speed curves are again very marked on Ranges III and IV.

Station E. Plates 16, 17, 18 *and* 19.

At Station E, at the top end of the Transporter Reach, there are mud flats on the north bank. These are about 200 feet broad and cover at half tide. At the beginning of the ebb a large quantity of water ebbs across these flats and so reduces the strength of the ebb in the channel. The main strength of the flood runs at a level between the surface and 1 fathom depth, except on Range I, where it is at 2 fathoms depth.

Station F. Plates 20, 21, 22 *and* 23.

Station F is also bounded by mud flats on the north side. The speeds of the currents are less than those at the stations higher up the river.

The highest speeds recorded were :—

Flood : 2·00 ft. per sec. at a depth of 2 fathoms at $2\frac{1}{2}$ hours before high water on Range IV.

Ebb : 3·20 ft. per sec. on the surface at $3\frac{3}{4}$ hours after high water on Range IV.

Station G. Plates 24, 25 *and* 26.

The currents at Station G are the weakest to be found in the estuary. On Range I the speeds were too small and variable to provide satisfactory data for drawing a curve. The highest speeds recorded were :—

Flood : 1·85 ft. per sec. at a depth of 2 fathoms at 3 hours before high water on Range IV.

Ebb : 3·00 ft. per sec. on the surface at 4 hours after high water on Range IV.

Station H. Plates 27, 28, 29 *and* 30.

The currents at Station H are much stronger than at G. At Station H the river is bounded on the north side by a training wall which covers at half tide. When the wall is covered, the water rapidly overflows on to the Seal Sands in very large quantities. This loss of water does not apparently affect the strength of the current in the main channel, as there is but little sign of any slackening at half flood. It is noticeable that on the flood the strength of the current does not vary greatly at different depths, but that on the ebb the speed falls off considerably as the depth increases. The highest speeds recorded were :—

Flood : 2·40 ft. per sec. at a depth of 2 fathoms at $2\frac{1}{2}$ hours before high water on Range IV.

Ebb : 3·50 ft. per sec. on the surface at 4 hours after high water on Range IV.

Station I. Plates 31, 32, 33 *and* 34.

The records for Station I are incomplete owing to bad weather. The station is bounded on both sides by training walls. The current is stronger than at H. A slight easing in the surface current at about 3 hours before high water on Range IV may be caused by the loss of water over the training walls. As at Station H, the flood runs at nearly the same strength at all depths, but the strength of the ebb falls off rapidly under the surface as the depth increases. Observations on Ranges I and II were interrupted by bad weather. The highest speeds recorded were :—

Flood : 4·60 ft. per sec. at a depth of 5 fathoms at $2\frac{3}{4}$ hours before high water on Range IV.

Ebb : 3·85 ft. per sec. on the surface at $3\frac{1}{2}$ hours after high water on Range IV.

Station K. Plates 35 *and* 36.

Station K is near the river mouth. The records are incomplete owing to bad weather and the difficulty of getting the current meter to the lower depths in the strong current. On the flood, Range I, the strength of the current does not

vary in any definite manner with depth, but on the ebb the strength falls off at the lower depths. The highest speeds recorded on Range IV were :—

Flood : 5·1 ft. per sec. at a depth of 2 fathoms at $2\frac{1}{2}$ hours before high water.

Ebb : 4·9 ft. per sec. on the surface at 3 hours after high water.

The flood, at the majority of stations, runs at its greatest strength at a depth below 1 fathom, and the ebb is without exception strongest on the surface. In general, the sub-surface current at 2 fathoms and greater depths floods for $6\frac{1}{2}$ hours or longer and ebbs for less than 6 hours, whilst at the surface and at a depth of 1 fathom the current ebbs for a longer period than it floods. At Station H and below, an interesting point is the apparent superiority of the average strength of the flood over that of the ebb ; this is explained on page 8. The highest recorded speed of current in the estuary is 5·1 ft. per sec. on the flood on Range IV at K.

In general it may be said that the currents are strong near the mouth of the river and become gradually weaker up to Station G, where the weakest recorded currents are found. From this point the strengths of the currents increase to Station C, and above this point there is a gradual decrease in strength.

For the purpose of calculating the volume of water passing a station at any particular time, it was necessary to make cross-sections of the river at each observing station. These cross-sections are shown diagrammatically in Plate 37, and a longitudinal section along the centre line of the dredged channel of the river from Stockton to the Fairway Buoy is given in Plate 37A. The sections in Plates 37 and 37A have been prepared from data supplied by the Tees Conservancy Commission. Complete cross-sections up to the level of High Water Springs are shown for Stations A to G inclusive. At Station H there is a training wall rising to a height of 7 feet above Low Water Springs on the north side of the main channel. Above this level the river overflows on to a broad stretch of sand. At I there are training walls on both sides and at I and K there are on both sides of the main channel broad stretches of sand which cover at about half tide. The calculations of volumes passing H, I and K have been confined to those moving in the main river channel only. The cross-sections are, therefore, shown only up to the level of Low Water Springs for Stations I and K and to the level of the top of the training wall on the north bank for Station H.

The current measurement diagrams, Plates 4 to 36, are based on readings taken in the centre of the river only. The current is strongest in the centre, in the normal course of events, and it is therefore necessary to make some correction in order to find the mean speed over the whole cross-section and hence the volume.

A complete examination of the side currents was made at Station F for all four ranges of tide, and a few observations were made at other stations. On each occasion two boats were used, one anchored in the centre of the river and the other working at the sides. The results of these observations are given in Table 2. This table gives the ratio of the average speed of the current over the whole cross-section of the river at the station specified to the average speed in the centre of the river for each hour before and after high water.

In a non-tidal river, running over an even bed, it has been found that the average speed of the current over the whole cross-section is 0·8 times that of the average speed in the centre line. Table 2 shows that this factor is approximately true for a tidal estuary. It will be noticed that the factor decreases as the range of tide increases and that it is smallest at one hour after high water. This may be due to the fact that the ebb begins to run down the centre of the river on the surface when the deeper water is still slack. It can be seen from Table 2 that the factor varies from about 0·7 to 0·9. For the purpose of calculating the volumes of water passing each station, it has been considered sufficiently accurate to use a factor of 0·8 throughout.

The average volumes of water passing Stations A to K inclusive for all ranges of the tide have been calculated from the products of the average areas of the cross-sections of layers of water 1 fathom in thickness at hourly periods of the tide, and the average speeds of the layers, taking into consideration the continual alteration in the water level. To facilitate this calculation, Table 3 was prepared from the current observations. This table shows the average speed of the current in feet per second for each layer of water of 1 fathom thickness for each hour. An example of the method of calculation of the volumes of water passing a station during a flood of 6 hours and an ebb of $6\frac{1}{2}$ hours is given in Table 4, and the results obtained by this method for the different stations are set out in Table 5.

It might be expected that the figures for the ebb on each range would normally be slightly in excess of those for the flood and that there would be a progressive increase in volume with a movement down river from Station A to Station K. In general the figures bear out this expectation within such limits of error as may be anticipated. The following factors, however, must be taken into consideration before a true comparison can be made :—

(1) Each range covers a variation in tidal range of 3 feet, and it may have happened that in one case the observations were all obtained near the upper limit of a range, whereas the corresponding ones for the next station or for the other tide on the same station were all obtained near the lower limit of the range.

(2) The section of the river below Cargo Fleet, Stations H, I and K, is very different in general character from the section between Stations A and G. At Stations H and I the river runs between training walls, and, when the flood commences, the water can pass up the river only between the walls until about half tide. It then overflows the walls and rapidly covers the sands on both sides to river level. The main force of the flood stream, however, runs at a depth of 2 fathoms or lower, so that it is kept between the training walls throughout the flood, and the overflow on the sands does not appreciably reduce the strength of the current between the walls ; there is hardly any up-river movement of the flood over the sands.

During the ebb the greatest strength of the current is at the surface, and, until the water falls to the level of the top of the training walls, the ebb runs not only between them but also across the sands. A large quantity of water which came up the river on the flood between the training walls, therefore, moves down river on the ebb across the sands. This accounts for the much smaller volumes obtained at H (except on Range I) and I, on the ebb than on the flood. The same considerations are applicable to K, where there are sand flats on both sides. It is for these reasons that the figures of the flood volumes at H, I and K, except on Range I, when the stream is confined nearly all the time within the training wall, show a considerable excess over those of the ebb volumes.

The volumes given in Table 5 have been plotted in Diagrams 1 and 2 against the precise ranges of tide at which the observations were made. From the curves thus obtained the volumes at four exact ranges of 6, 9·5, 13 and 16·5 feet have been derived, and these are given in Table 6. The figures in Table 5 for Stations I and K and those of the ebb volumes for the two highest ranges of tide at Station H have not been included in Diagrams 1 and 2, for, as already explained, they cannot properly be compared with the volumes at Stations A to G.

It has been assumed that for each range of tide the volume of water passing the various stations during a tidal period of $12\frac{1}{2}$ hours should increase with a movement down river from A to K, and should give a fairly even curve when plotted against the distances along the river. Diagrams 3 and 4, for the flood and ebb respectively, have been prepared from Table 6 by plotting the volumes against the distances. The lack of a complete series of observations at I and K precludes the results at these stations being included in the diagrams, and, in any case, the different character of the river over this section prevents a fair comparison with the section between A and G. It is for the latter reason that the volumes at H on the ebb for Ranges III and IV have not been plotted ; the figures in Table 5 show that comparable results for the ebb at this station cannot be obtained from observations in the centre line only.

An inspection of Diagrams 3 and 4 will show that, in general, fair curves can be drawn to fit the points for each range, the observed values being within about 10 per cent. of those obtained from the curve, with the exception of the volumes at Station B on Range IV on the ebb, which for some unknown cause are not in good agreement. The volumes for the ebb at Stations H, I and K can, for reasons already explained, only be considered to represent those passing in the main channel.

Final figures for the volumes passing Stations A to G have been read from the curves in Diagrams 3 and 4, and are shown in Table 7 ; those for H, I and K are given separately in Table 8.

Upper River at Winter Level

With the river at normal winter level, 1 ft. 9 in. on the gauge at Croft Bridge, the estimated fresh water discharge into the estuary is 23 million cubic feet, or 143 million gallons in 12 hours. This quantity will be absorbed into the estuary on each ebb.

Tables 7 and 8 show the estimated volumes moving past the observing stations with the upper river at summer level, when the volume of fresh water discharged is of the order of 8 million cu. ft. in 12 hours. The difference between summer and winter discharge is about 15 million cubic feet in 12 hours. From Table 7 it will be seen that this extra water moving down on the ebb will appreciably affect the volumes moving in Range I at all stations from A to G. As the range increases, this effect is proportionately less, until on Range IV in the Transporter Reach, between Stations E and G, and below, the extra volume is small in comparison with the tidal streams.

Observations of the tidal streams with the upper river at normal winter level have been few, but from those which have been made it would appear that the general effect of the comparatively small quantity of extra water moving down river is to increase the speed of the ebb on the surface and of the flood in the lower layers. The tidal streams at stations below G are so slightly affected by a rise of the upper river to winter level that the differences are hardly measurable by current meter. The effect, therefore, caused by the rise of the river to winter level is a general speeding up of the ebb and flood in the upper reaches of the estuary, but this effect grows weaker as the range of tide increases and as the water moves down towards the sea. The condition of the river will not be altered appreciably except that a larger volume of water will reach the sea on each tide and the " swing " of the water up and down the river (Plates 38 to 40) will be over a greater distance.

Upper River in Flood

Large alterations in the tidal streams take place when heavy rain causes a spate in the upper river. As previously mentioned, a spate passes down river very quickly and the upper river seldom remains at a high level for more than a few hours. If the spate water reaches the estuary while the flood stream is running, it will be banked up in the upper reaches and will hold back the salt water to an extent depending on the amount of fresh water. When the tidal stream turns, the fresh water which was banked up by the salt water will run off through the estuary. If the spate water reaches the estuary during an ebb it will run straight through and the force of the ebb will not be so great as in the case where the fresh water is banked up by the previous flood.

The following particulars obtained from current observations made in the estuary on 11th December, 1929, are of interest. The spring flood was entirely held up for $2\frac{1}{2}$ hours at the top end of the Transporter Reach and only passed Furness Shipyard when it commenced to run its full force at 3 hours before high water. In the meantime the water at Victoria Bridge, Stockton, was moving down river. A large body of water was, therefore, banked up between Furness Shipyard and Stockton. During this period the water level throughout was rising at its normal rate. At 3 hours before high water the full strength of the flood commenced to work up Billingham Reach and the water above was pushed back up river. At about 1 hour before high water, owing to the strength of the flood tide easing, the banked-up water commenced to move down river and developed into a very swift ebb. In this instance the durations of slack water, flood and ebb in Billingham Reach were : $2\frac{1}{2}$ hours slack water, $2\frac{1}{2}$ hours flood, $7\frac{1}{2}$ hours ebb. These times are much the same as those found at Yarm under normal conditions. During the spate on 11th December, when these observations were made, the river rose to 8 ft. on the gauge at Croft at noon, but was varying considerably most of the day.

The large rises of about 16 ft. in the upper river which occurred in November and December, 1929, probably swept through the estuary and entirely held back the flood as far down river as Cargo Fleet. Unfortunately, current observations could not be obtained during these heavy spates.

The observations obtained render it possible to make the following general summary of the tidal movements when the upper river is at winter level or in spate :—

1. Under normal winter conditions with little rain, the gauge at Croft will read about 1 ft. 9 in., equivalent to a discharge of about 23 million cubic feet, or 143 million gallons of fresh water in 12 hours. The tidal streams in the river will not be very different from those found under summer conditions.
2. When the upper river is in spate, the water passes down very quickly and, unless heavy rain continues in the catchment area, the estuary soon regains its normal tidal movement, probably in one or two tides.
3. Observations of the river under fresh water spate conditions are not easy to carry out owing to the difficulty of timing the arrival of spate water in the estuary, the constant variation in the volume of fresh water moving down, and the variation in the range of the tide.

An accurate survey of the river under conditions of spate would entail an elaborate system of rainfall observations in the catchment area and constant watching of the movement of fresh water floods all down the river to the tidal area. In the tidal area itself a further complete series of observations would have to be taken over a long period.

MOVEMENT OF WATER TOWARDS THE SEA

An examination of the current speed diagrams in Plates 4–36 shows that the main force of the flood flows subsurface at a depth of about 2 fathoms, while on the ebb the current flows fastest on the surface. This results from the natural tendency of the less dense fresh water from the upper river to remain in the surface layers and of the more dense salt water to remain in the lower layers.

If it were possible for the body of water constituting the top fathom layer to remain unmixed with the water below, its movement could be calculated from the current measurements. The diagram in Plate 38 shows the movement of such a body of water or float moving from Station B in the top fathom layer. The ebb in that layer is much stronger than the flood and during each full period of ebb and flood there is a resultant movement towards the sea. The diagram in Plate 39 shows the movement from Station B of such a body of water or float in the top 2-fathom layer. The movement is again down river, but rather less owing to the strong flood at 2 fathoms working against the down river movement in the top fathom layer. The diagram in Plate 40 shows the apparent movement from Station B calculated from the average speeds at all depths.

At depths below 1 fathom the water has a definite tendency to move up river over each full period of ebb and flood. This conclusion is derived from current meter readings, the calculated volumes moving in different layers, and from observations of a float moving with the 1–2 fathom layer during 12½ hours on 17th and 18th September, 1929.

To counteract this up-river movement in the lower depths, the water at the surface down to a depth of 1 fathom has a strong movement down river. The volume of water moving down river in the top layer is greater than the volume moving up river in the lower layers. This must be so, otherwise the fresh water continually entering the tidal area would not be carried out to sea. For example, the net volumes which passed Station D on 17th and 18th September, 1929, in the different layers during a full period of ebb and flood were :—

	Up River cu. ft.	*Down River* cu. ft.
Surface—1 fathom	—	43,620,000
1 fathom—2 fathoms ..	230,000	
2 fathoms—3 fathoms ..	20,500,000	
3 fathoms—4 fathoms ..	13,750,000	
4 fathoms—5 fathoms ..	5,090,000	
	39,570,000	43,620,000

A preponderating down river movement only occurs in the top layer, but the volume carried is greater than that moving up river in all other layers. The level of the water at Croft Bridge was unusually low on 17th September, varying from 6 to 9 in. on the gauge. The difference of about 4 million cu. ft. between the net volumes of the ebb and flood should be of the same order as the quantity of fresh water discharged, though close agreement is not to be expected owing to changes in the tidal range. The agreement in this instance, however, is good, as from the curve in Plate 3 it may be calculated that the volume of fresh water passing Croft Bridge with the level of the river at 7 in. on the gauge is approximately 4 million cu. ft. during 12½ hours.

If floats were placed vertically above one another in each fathom layer at a particular position at high water, then at the end of a full tide the positions of these floats would have altered considerably. The float in the top fathom layer would be well down river, but the lower floats would all be up river and the float in the 2–3 fathom layer would have moved furthest up river. This illustrates that, in order to show a net movement down river the water must get into the top fathom layer. Although the water is continually mixing, any matter heavier than water as it slowly sinks will have a tendency to be carried up river.

From the figures in Table 1, the sluggish movement of the water at Station G is noticeable. Both on the ebb and flood the velocities at that station are smaller than those at stations above and below. This is due to the fact that the cross section at G is greater than at the stations immediately above and below. A slackening of current also takes place at Furness Shipyard, but this has not been allowed for in constructing Plates 38 to 40, since no current readings were made there.

From the diagrams in Plate 40, showing the average movement of currents at all depths over an ebb and flood, it would appear that the water tends to return to the same place at each time of high water, and therefore to have no net movement towards the sea. This is because the diagrams are constructed from current readings in the centre of the river only and do not show volumes. If volumes are taken into consideration as well as speeds, the down river movement is made clear. The river channel is broader at the top than at the bottom and the current in the top layer affects a greater volume of water than the subsurface current. This results in a definite net movement down river.

Over a long period the amount of water working down to the sea would be equal to the amount of fresh water entering the estuary from the upper river. This quantity reaching the sea is continually changing owing to the fluctuation in the amount of fresh water and the alteration of the tidal range in building up to and falling away from spring tides. The result of a long period of observations would show the total amount of fresh water reaching the sea during a given time. From this a calculation could be made for the average run of the fresh water through the estuary, taking into account the cubic capacity of the estuary, water levels, etc. The results thus obtained, however, would be of doubtful value, since the normal fresh water flow is so minute when compared with the amount due to tidal movement.

The Seal Sands assist the water to reach the sea, since they dry at each low water. Any water overflowing on to the Seal Sands may be considered to reach the sea in one tide, and any small quantity which may return up river again would be much diluted with sea water. In the diagrams in Plates 38–40 no allowance has been made for the Seal Sands, the water remaining in the river channel between the training walls only being taken into consideration. To sum up, it may be assumed that any water reaching the Seal Sands gets to sea on the same tide, but that water in the river channel continues to flow up and down the river, only a small quantity being released at each tide.

WATER LEVELS AND TIMES OF HIGH AND LOW WATER IN THE ESTUARY

There are numerous tide gauges in the estuary. During May and June, 1929, the Engineer to the Tees Conservancy Commission carried out a re-survey of the levels of all gauges and made corrections where necessary. The corrected zero mark on all gauges shows Admiralty chart datum level or 8·40 ft. below Ordnance Datum (Liverpool). With the assistance of the Engineer to the Tees Conservancy Commission, who very kindly supplied the necessary men and boats,

series of tide gauge readings were made on three occasions: (1) 26th July, range 12 ft., readings during 13 hours; (2) 29th August, range 8 ft., readings during 13 hours; (3) 3rd–4th October, range 17 ft., readings during 14 hours. On each occasion simultaneous observations were made at 10 positions from Yarm to the river mouth. Gauge readings were taken every 5 minutes from 1 hour before till 1 hour after high and low water and at 10-minute intervals at other times. The results obtained are plotted in the diagrams shown in Plates 41–46.

Plates 41–43 show the tidal curves for 5th Buoy, Preston and Yarm, and include tables giving times and heights of high and low water at other positions where observations were made. On the lower ranges (Plates 41 and 42) there is little difference between the times of high and low water at the positions in the dredged channel. On the high spring tide (Plate 43) the times of high and low water at Corporation Quay, Stockton, are 15 and 25 minutes respectively after the times of high and low water at 5th Buoy. At Preston, midway between Stockton and Yarm, the times of high and low water relative to the times at 5th Buoy are :—

	High Water	*Low Water*
8 ft. range ..	35 mins. after	1 hr. 15 mins. after
12 ft. range ..	35 mins. after	1 hr. 55 mins. after
17 ft. range ..	35 mins. after	1 hr. 25 mins. after

At Yarm the times relative to 5th Buoy are :—

	High Water	*Low Water*
8 ft. range ..	40 mins. after	4 hrs. after
12 ft. range ..	1 hr. after	3 hrs. 55 mins. after
17 ft. range ..	50 mins. after	3 hrs. 40 mins. after

The diagrams in Plates 44–46 show the water levels at each hour of ebb and flood at the various positions compared with levels at 5th Buoy. In the dredged channel, on the ebb, there is shown a slope towards the sea reaching a maximum difference of level of 2 ft. 3 ins. at Corporation Quay, Stockton, above the level at 5th Buoy on the 17 ft. range. The slope is less steep on the smaller ranges. On the flood, the levels in the dredged channel tend to fall below the level at 5th Buoy, but the differences in levels are not so marked as on the ebb tide.

DEPOSITION OF SILT IN RIVER

The Tees Conservancy Commission carry out very complete dredging operations throughout the year. During the period 1908 to 1928, 14 million cubic yards of material were dredged from the river and deposited on spoil ground at sea.

Siltation occurs chiefly in the following positions: (1) Seaton Channel, sand; (2) at the bend of the river between 9th and 7th Buoys, sand; (3) at the bend of the river above Cargo Fleet, black mud; (4) N.E. Railway Dock cut, black mud; (5) Transporter Reach, black mud; (6) Opposite Furness Shipyard, south side, black mud; (7) Newport Corner, south side, mud; (8) Stockton, black mud.

The siltation in Seaton Channel is caused by sand washed off the Seal Sands by the ebb. The accumulations at positions 2, 3, 6, 7 and 8 are the result of eddies caused by bends in the river. At position 4, the water is cut off from the main strength of the current and the deposition of solid matter thus takes place. At position 8, the bends in the river at Stockton tend to increase deposition, which may also be partly caused by drainage from the town. At position 5, Transporter Reach, the deposit consists of a thick black oily slime, in places to a depth of many feet; the current in this area is weaker than in the rest of the river. In Billingham Reach, the river bed, although having a deposit, is cleaner than in the Transporter Reach. Above Newport the river bed is fairly free from deposits and consists of a firm mud. In the narrow reach above Newport the strength of the current tends to keep solid matter in suspension, but on moving down below Furness Shipyard, deposition can take place. Even if deposition takes place in the narrow reaches during high and low water slack, the strong current of the next tide tends to put any deposit in suspension again. In the Transporter

Reach, however, where the river is broader and the current weaker, the deposition is more likely to take place. The bed of the river from the mouth to Jack-in-the-Box Light is generally of a sandy nature, but above that point the bottom consists of mud.

During spates in the upper river, tree roots and stumps travel down the river, and these are carefully watched and removed by the Tees Conservancy Commission. When these obstacles become water-logged, they tend to sink and do not usually move further down than the Billingham Reach.

CONCLUSION

The most important fact brought out by this hydrographical survey of the River Tees is that at some points there are considerable differences between the surface and deeper waters, and that at certain times the flood is running up-stream below the surface while the ebb is still running on the surface. This phenomenon is due to the difference of density between fresh and salt water and would not occur if the North Sea were fresh. If we imagine for a moment that there are no tides, that the estuary is separated from the sea by a sluice gate, and that it is full of fresh water, then it is easy to see that if the gate were removed the fresh water would spread out over the surface of the sea and the heavy salt water would force its way up stream along the bottom in a wedge gradually thinning out to nothing. The river water running seaward over the heavy bottom water would continually pick some of the latter by turbulent mixing and carry it away with it, and the salt water so removed would be continuously replaced from the sea. Thus the surface current would set up a bottom current in the opposite direction, the speed of which would increase as the surface speed increased, until the latter became so great as to sweep all seawater out of the estuary. If now tidal action were added, the two currents would flow as before, and at the same time the whole system would oscillate up and down the estuary. The observations have shown that this is what actually happens, with the difference that the maximum speed of the flood is at one or two fathoms below the surface and not on the bottom. The bottom layers are considerably retarded by friction against the bed of the river.

The conclusion may be drawn that polluting matter cannot escape seawards easily unless it is in the surface layer. This is of importance in considering the discharge of effluents.

The current measurements show the difference between the speeds at various depths; but since they were made only at depth intervals of one fathom, they do not give more than a very rough idea of the thickness of the upper layer, and naturally give no information as to the differences of density on which the "pumping" action of the fresh water depends. The observations of salinity which are being made as part of the chemical survey, when combined with the current measurements, should give a clearer picture of the whole regime.

The experience of the survey has shown that the method of measurement of currents by means of floats is not suitable for a tidal estuary, where the water is divided into layers and a float might take many days to reach the sea even if it were not caught up in an eddy.

Observations made at station F show that there, at least, the velocity in the whole cross-section can be obtained approximately by multiplying the velocity in the centre line by 0·8. It is hoped that more information on this point will be gained during the chemical survey, but it is doubtful whether such a factor has any real meaning in an estuary, except where one is dealing with the average of a large number of observations.

In future surveys of an estuary, attention should be directed to obtaining accurate measurements of the thickness of the upper layer. This might be done by keeping a weighted current drag hanging over the side when making current measurements from a boat at anchor and noting at what depth the line leads forward instead of aft. Closely spaced observations of temperature and salinity made at the same time would enable density sections to be drawn, from which some idea of the magnitude of the pumping effect could be obtained, while the salinities alone would make it possible to calculate the volume of the water moving in the two layers by means of the theorem of Professor Martin Knudsen.

APPENDIX

THE following current meters, in which indications of velocities are given by means of an electric contact system and a telephone receiver, were used during the hydrographical work described in this report :—(i) small Watts meter ; (ii) small Gurley-Price meter ; (iii) large Gurley-Price meter ; (iv) Merz-Ekman meter.

The small Watts and Gurley-Price meters were generally employed and, although in constant use for seven months, they proved to be fairly satisfactory. The chief difficulty experienced with these meters was that the " wipers " in the contact chambers were continually corroding and breaking. New " wipers " had to be fitted each week. The corrosion was considerably diminished by filling the contact chamber with vaseline to prevent the intrusion of sea water. In warm summer weather vaseline is quite satisfactory, and does not interfere with the current " make and break," but in cold weather the vaseline causes resistance in the contact chamber and congeals around the upper end of the vane spindle. In cold weather a medium more fluid than vaseline is advisable. The corrosion of the " wiper " is mainly due to the chlorine set free by the action of the electric current on the sea water, and when these instruments are used in brackish or sea water the contact box should be filled with some protective medium. The current meters were periodically checked, and appeared to retain their accuracy throughout the survey.

The observations recorded in this report are necessarily approximate, and such errors as may exist may possibly be due to the following causes :—(1) The difficulty of ascertaining the exact depth of the current meter in strong currents owing to the curve in the cable ; (2) calibration error of current meter, this is probably not more than 1 per cent. ; (3) any movement of the boat tends to make the current meter give a higher reading than the true speed of the current ; (4) as at all observing stations except at Station F, the volumes have been calculated from readings made in the centre of the river only, there may be an error in the assumed coefficient of 0·8 ; (5) no allowances have been made for the " falling off " from and " making up " to spring tides ; (6) no allowances have been made for small fluctuations in the level of the upper river during a particular series of observations in the estuary ; (7) the exact times when small fresh water spates entered the tidal area were not ascertained ; (8) observations were made only at intervals of depth of 1 fathom.

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom*

Direction of Flow : Flood + and Ebb —

STATION A—RANGE II.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·7 −	0·3 −	0·0	0·25+	0·5 +	1·3 +	1·25+	1·15+	1·2 +	1·3 +	0·95+	0·3 +	0·0	0·4 −	1·1 −	1·5 −	1·5 −	1·45−	1·75−	1·8 −	1·8 −	1·6 −	1·3 −	0·95−	0·9 −	0·7 −
1 fathom	0·0	0·45+	1·0 +	1·5 +	1·7 +	1·7 +	1·5 +	1·4 +	1·55+	1·6 +	1·55+	1·05+	0·65+	0·0	0·85−	1·45−	1·5 −	1·6 −	1·7 −	1·6 −	1·75−	1·5 −	1·25−	0·8 −	0·6 −	0·0
2 fathoms	0·3 +	0·55+	0·75+	1·15+	1·3 +	1·7 +	1·3 +	1·25+	1·45+	1·2 +	1·3 +	0·95+	0·45+	0·0	0·9 −	1·0 −	1·3 −	1·55−	1·65−	1·6 −	1·5 −	1·45−	1·1 −	0·9 −	0·75−	0·3 −
3 „	—	—	—	—	—	—	—	—	1·0 +	0·8 +	0·9 +	0·65+	0·35+	0·2 +	0·6 −	0·75−	0·9 −	—	—	—	—	—	—	—	—	—

STATION B—RANGE I.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·85−	0·25−	0·25+	0·45+	0·6 +	0·7 +	0·7 +	0·65+	0·5 +	0·3 +	0·15+	0·0	0·1 −	0·15−	0·3 −	0·55−	0·8 −	1·05−	1·3 −	1·45−	1·55−	1·45−	1·55−	1·35−	1·1 −	0·8 −
1 fathom	0·2 −	0·1 +	0·5 +	0·8 +	0·8 +	1·05+	1·5 +	1·65+	1·55+	1·3 +	1·0 +	0·7 +	0·3 +	0·35−	0·65−	1·0 −	1·45−	1·6 −	1·5 −	1·35−	1·3 −	1·05−	1·0 −	0·9 −	0·7 −	0·45−
2 fathoms	0·25+	0·65+	0·7 +	0·7 +	0·85+	1·1 +	1·25+	1·2 +	1·1 +	0·95+	0·7 +	0·45+	0·0	0·45−	0·75−	0·9 −	0·9 −	0·9 −	0·9 −	0·85−	0·75−	0·6 −	0·5 −	0·45−	0·3 −	0·05+
3 „	—	—	—	—	—	—	—	0·7 +	0·7 +	0·75+	0·8 +	0·55+	0·0	0·3 −	0·4 −	0·55−	0·65−	0·7 −	—	—	—	—	—	—	—	—

STATION B—RANGE III.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·85−	0·65−	0·55−	0·0	0·5 +	0·7 +	0·75+	1·2 +	1·8 +	1·8 +	1·15+	0·75+	0·1 −	0·7 −	1·4 −	1·8 −	2·2 −	2·35−	2·2 −	2·15−	2·35−	2·5 −	2·25−	1·85−	1·4 −	0·9 −
1 fathom	0·0	0·45+	0·9 +	1·4 +	1·9 +	2·1 +	2·05+	1·95+	2·0 +	1·9 +	1·55+	0·9 +	0·35+	0·3 −	1·0 −	1·6 −	1·85−	1·9 −	1·75−	1·85−	2·0 −	2·0 −	1·65−	1·3 −	0·8 −	0·0
2 fathoms	0·25+	0·7 +	1·1 +	1·25+	1·4 +	1·55+	1·6 +	1·8 +	1·75+	1·8 +	1·7 +	1·45+	0·7 +	0·0	0·55−	0·85−	1·1 −	1·3 −	1·3 −	1·55−	1·5 −	1·4 −	1·0 −	0·35−	0·25+	0·4 +
3 „	—	—	—	—	—	—	—	1·45+	1·4 +	1·4 +	1·4 +	1·2 +	0·55+	0·0	0·4 −	0·5 −	0·5 −	0·45−	—	—	—	—	—	—	—	—

STATION B—RANGE IV.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	1·35−	0·7 −	0·1 −	0·55+	1·2 +	1·4 +	1·5 +	2·1 +	2·75+	2·5 +	1·8 +	1·05+	0·2 +	0·6 −	1·45−	2·2 −	2·65−	2·7 −	2·7 −	2·75−	2·95−	2·85−	2·4 −	2·15−	1·75−	1·35−
1 fathom	1·1 −	0·65−	0·2 −	0·75+	1·3 +	1·6 +	2·0 +	2·7 +	3·1 +	2·85+	2·3 +	1·6 +	0·85+	0·05+	0·75−	1·65−	2·1 −	2·15−	2·3 −	2·45−	2·55−	2·4 −	2·0 −	1·8 −	1·35−	0·85−
2 fathoms	—	—	—	1·0 +	1·3 +	1·5 +	1·9 +	2·5 +	2·85+	2·75+	2·35+	1·7 +	1·0 +	0·25+	0·5 −	1·2 −	1·7 −	1·65−	1·75−	2·0 −	2·1 −	1·9 −	1·45−	1·35−	—	—
3 „	—	—	—	—	—	—	—	—	1·9 +	2·1 +	1·8 +	1·3 +	0·85+	0·25+	0·3 −	0·7 −	0·9 −	0·75−	0·75−	0·85−	—	—	—	—	—	—
4 „	—	—	—	—	—	—	—	—	—	—	1·1 +	0·8 +	0·5 +	0·15+	0·2 −	0·45−	—	—	—	—	—	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow : Flood + and Ebb −

STATION C—RANGE I.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·65−	0·3 −	0·2 +	0·55+	0·95+	1·15+	1·3 +	1·2 +	0·8 +	0·65+	0·35+	0·3 −	0·65−	1·2 −	1·7 −	2·0 −	2·4 −	2·5 −	2·5 −	2·3 −	2·05−	1·95−	1·9 −	1·7 −	1·4 −	0·95−
1 fathom	0·5 −	0·1 −	0·35+	0·8 +	1·45+	1·85+	1·95+	1·65+	1·25+	1·05+	0·8 +	0·25+	0·2 −	0·45−	0·65−	1·25−	1·7 −	1·95−	2·0 −	2·05−	1·95−	1·85−	1·55−	1·2 −	0·9 −	0·55−
2 fathoms	0·65+	1·0 +	1·5 +	1·8 +	1·9 +	1·95+	2·0 +	1·85+	1·55+	1·3 +	1·0 +	0·7 +	0·4 +	0·05−	0·5 −	0·9 −	1·3 −	1·35−	1·2 −	0·9 −	0·8 −	0·55−	0·45−	0·3 −	0·15+	0·65+
3 „	—	—	—	—	1·2 +	1·4 +	1·6 +	1·4 +	1·3 +	1·3 +	1·15+	0·85+	0·5 +	0·0	0·35−	0·6 −	0·9 −	0·8 −	0·65−	0·45−	0·45−	0·4 −	—	—	—	—

STATION C—RANGE II.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·9 −	0·15−	0·7 +	1·15+	1·35+	1·8 +	1·6 +	1·4 +	1·3 +	1·0 +	0·6 +	0·0	0·5 −	0·95−	1·75−	2·25−	2·65−	2·95−	3·05−	3·25−	3·2 −	2·8 −	2·1 −	1·7 −	1·6 −	0·8 −
1 fathom	0·7 −	0·2 +	0·55+	1·25+	1·45+	1·65+	1·6 +	1·7 +	1·8 +	1·6 +	1·25+	0·6 +	0·15+	0·3 −	0·9 −	1·65−	2·1 −	2·35−	2·65−	2·75−	2·6 −	2·35−	1·75−	1·5 −	1·3 −	0·6 −
2 fathoms	0·6 +	1·05+	1·75+	2·0 +	2·05+	1·95+	1·85+	1·7 +	1·6 +	1·5 +	1·25+	0·9 +	0·55+	0·0	0·75−	1·35−	1·5 −	1·4 −	1·5 −	1·55−	1·5 −	1·35−	0·6 −	0·35−	0·2 −	0·5 +
3 „	—	—	—	—	1·4 +	1·35+	1·25+	1·55+	1·45+	1·2 +	0·95+	0·75+	0·55+	0·2 +	0·4 −	0·55−	0·55−	0·4 −	0·3 −	0·2 −	—	—	—	—	—	—

STATION C—RANGE III.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·95−	0·85−	0·4 −	0·75+	1·45+	1·45+	1·8 +	2·15+	1·9 +	1·55+	0·8 +	0·35+	0·05−	1·0 −	1·85−	2·55−	2·95−	2·9 −	2·8 −	3·05−	3·4 −	3·25−	2·65−	2·35−	1·85−	1·1 −
1 fathom	0·35−	0·35+	0·65+	1·75+	1·75+	1·75+	2·1 +	2·55+	2·8 +	2·3 +	1·35+	0·8 +	0·2 +	0·2 −	1·0 −	1·85−	2·4 −	2·45−	2·5 −	2·7 −	3·0 −	2·75−	2·1 −	1·8 −	1·1 −	0·4 −
2 fathoms	0·85+	1·4 +	2·1 +	2·3 +	2·25+	2·3 +	2·75+	3·0 +	2·45+	2·25+	1·5 +	1·1 +	0·7 +	0·1 −	0·75−	1·55−	1·6 −	1·7 −	2·0 −	2·2 −	2·3 −	2·25−	1·5 −	1·0 −	0·3 −	0·7 +
3 „	—	—	—	1·65+	1·9 +	1·75+	2·0 +	2·3 +	2·55+	2·15+	1·4 +	0·9 +	0·35+	0·2 −	1·0 −	1·3 −	1·2 −	1·05−	1·0 −	1·1 −	1·2 −	1·1 −	—	—	—	—

STATION C—RANGE IV.

	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	1·25−	0·45−	0·6 +	2·15+	2·5 +	2·2 +	2·2 +	2·65+	2·9 +	2·35+	1·8 +	1·15+	0·5 +	0·9 −	1·85−	3·05−	3·35−	3·3 −	3·35−	4·25−	4·9 −	3·9 −	3·0 −	2·7 −	2·2 −	1·4 −
1 fathom	1·35−	0·0	0·9 +	1·95+	2·5 +	2·5 +	2·65+	3·2 +	3·2 +	2·8 +	2·3 +	1·5 +	0·8 +	0·3 −	1·3 −	2·35−	2·8 −	2·8 −	3·0 −	3·7 −	3·9 −	3·2 −	2·6 −	2·35−	1·95−	1·6 −
2 fathoms	0·85−	0·0	0·8 +	1·6 +	2·3 +	2·6 +	3·15+	3·7 +	3·7 +	2·95+	2·4 +	1·8 +	0·9 +	0·05+	0·9 −	1·8 −	2·35−	2·55−	2·8 −	3·3 −	3·4 −	2·5 −	1·85−	1·6 −	1·25−	0·8 −
3 „	—	—	—	—	1·65+	1·75+	2·4 +	3·25+	3·6 +	2·5 +	2·2 +	1·55+	0·8 +	0·1 −	0·75−	1·5 −	1·75−	1·85−	2·1 −	2·35−	2·35−	2·15−	—	—	—	—
4 „	—	—	—	—	—	—	2·1 +	2·5 +	2·6 +	2·4 +	2·0 +	1·35+	0·7 +	0·1 −	0·6 −	1·1 −	1·4 −	1·25−	—	—	—	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow : Flood + and Ebb —

STATION D—RANGE I.

	Before High Water												High Water	After High Water											
Time in Hours :	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·6 −	0·5 −	0·4 −	0·4 −	0·4 −	0·2 −	0·15+	0·35+	0·4 +	0·2 +	0·05−	0·45−	0·8 −	1·15−	1·45−	1·65−	1·8 −	1·9 −	1·9 −	2·0 −	2·0 −	1·8 −	1·4 −	1·1 −	0·85−	0·6 −
1 fathom	0·2 −	0·5 +	0·5 +	0·65+	0·85+	0·95+	1·0 +	0·85+	0·75+	0·6 +	0·5 +	0·35+	0·15+	0·2 −	0·55−	0·85−	1·15−	1·3 −	1·35−	1·35−	1·35−	1·3 −	1·1 −	0·8 −	0·5 −	0·25−
2 fathoms	0·4 +	0·95+	1·35+	1·5 +	1·5 +	1·5 +	1·45+	1·35+	1·25+	1·15+	1·0 +	0·8 +	0·5 +	0·15+	0·3 −	0·6 −	0·8 −	0·8 −	0·75−	0·6 −	0·45−	0·3 −	0·15−	0·0	0·15+	0·4 +
3 „	—	—	—	0·5 +	0·65+	0·9 +	1·0 +	1·0 +	0·95+	0·9 +	0·8 +	0·55+	0·3 +	0·0	0·25−	0·35−	0·35−	0·4 −	0·3 −	0·25−	0·15−	—	—	—	—	—

STATION D—RANGE II.

	Before High Water												High Water	After High Water											
Time in Hours :	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·9 −	0·4 −	0·0	0·4 +	0·7 +	1·0 +	1·5 +	1·55+	1·4 +	1·2 +	0·7 +	0·1 +	0·5 −	1·05−	1·5 −	1·8 −	2·1 −	2·3 −	2·45−	2·4 −	2·35−	2·15−	1·85−	1·55−	1·25−	0·9 −
1 fathom	0·7 −	0·05+	0·6 +	0·85+	1·2 +	1·45+	1·5 +	1·5 +	1·35+	1·0 +	0·7 +	0·25+	0·2 −	0·6 −	1·0 −	1·4 −	1·65−	1·8 −	2·0 −	2·15−	2·0 −	1·7 −	1·45−	1·15−	0·95−	0·7 −
2 fathoms	0·6 +	0·8 +	1·1 +	1·45+	1·6 +	1·6 +	1·6 +	1·6 +	1·5 +	1·3 +	0·9 +	0·5 +	0·15+	0·2 −	0·55−	0·8 −	1·1 −	1·25−	1·3 −	1·25−	1·05−	0·7 −	0·5 −	0·2 −	0·2 +	0·6 +
3 „	—	—	—	—	0·9 +	0·95+	1·0 +	1·05+	1·05+	0·95+	0·75+	0·4 +	0·1 +	0·2 −	0·4 −	0·65−	0·75−	1·0 −	1·1 −	1·0 −	0·8 −	—	—	—	—	—
4 „	—	—	—	—	—	—	—	—	0·75+	0·65+	0·5 +	0·3 +	0·15+	0·0	0·25−	0·4 −	0·45−	—	—	—	—	—	—	—	—	—

STATION D—RANGE III.

	Before High Water												High Water	After High Water											
Time in Hours :	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·8 −	0·25−	0·25+	0·45+	0·6 +	0·9 +	1·4 +	1·75+	1·8 +	1·5 +	0·9 +	0·2 +	0·6 −	1·05−	1·5 −	2·1 −	2·35−	2·4 −	2·45−	2·65−	2·65−	2·35−	2·0 −	1·65−	1·25−	0·85−
1 fathom	0·4 −	0·1 +	0·5 +	0·8 +	1·1 +	1·4 +	1·75+	2·0 +	2·0 +	1·75+	1·2 +	0·75+	0·35+	0·1 −	0·65−	1·2 −	1·65−	1·9 −	2·2 −	2·5 −	2·55−	1·9 −	1·45−	1·15−	0·75−	0·4 −
2 fathoms	0·45+	1·0 +	1·55+	1·85+	1·95+	1·7 +	1·6 +	2·05+	2·35+	2·1 +	1·4 +	1·05+	0·6 +	0·0	0·6 −	1·3 −	1·5 −	1·5 −	1·7 −	1·9 −	1·8 −	1·4 −	0·95−	0·45−	0·05+	0·45+
3 „	—	—	—	—	1·0 +	1·25+	1·35+	1·65+	1·7 +	1·6 +	1·35+	1·1 +	0·6 +	0·0	0·5 −	1·1 −	1·0 −	0·9 −	0·9 −	1·1 −	1·15−	—	—	—	—	—
4 „	—	—	—	—	—	—	—	—	1·5 +	1·35+	1·05+	0·7 +	0·3 +	0·15−	0·45−	0·7 −	0·75−	—	—	—	—	—	—	—	—	—

STATION D—RANGE IV.

	Before High Water												High Water	After High Water											
Time in Hours :	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·8 −	0·3 −	0·25+	0·6 +	0·8 +	0·95+	1·05+	1·4 +	1·55+	1·50+	1·25+	0·75+	0·2 +	0·5 −	1·15−	1·8 −	2·6 −	3·05−	2·95−	3·05−	3·5 −	3·6 −	2·65−	2·3 −	1·7 −	0·8 −
1 fathom	0·3 −	0·3 +	0·85+	1·3 +	1·6 +	1·7 +	1·75+	1·9 +	1·95+	1·9 +	1·7 +	1·25+	0·6 +	0·2 −	1·0 −	1·65−	2·2 −	2·55−	2·6 −	2·9 −	3·1 −	2·6 −	1·8 −	1·55−	1·25−	0·3 −
2 fathoms	0·1 +	0·65+	1·15+	1·55+	1·9 +	2·1 +	2·5 +	2·6 +	2·4 +	2·2 +	1·95+	1·5 +	0·9 +	0·0	0·8 −	1·45−	1·9 −	1·95−	2·1 −	2·1 −	2·25−	1·7 −	1·05−	0·7 −	0·5−	0·1 +
3 „	—	—	—	—	1·4 +	1·8 +	2·0 +	2·15+	2·15+	2·05+	1·8 +	1·35+	0·75+	0·1 −	0·6 −	1·15−	1·55−	1·65−	1·6 −	1·25−	—	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow: Flood + and Ebb −

STATION E—RANGE I.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·0	0·0	0·0	0·0	0·05+	0·25+	0·35+	0·4 +	0·4 +	0·35+	0·2 +	0·05−	0·4 −	0·9 −	1·0 −	1·0 −	1·05−	1·2 −	1·35−	1·55−	1·55−	1·4 −	1·0 −	0·5 −	0·1 −	0·0
1 fathom	0·25+	0·7 +	0·85+	0·75+	0·8 +	1·0 +	1·0 +	0·85+	0·7 +	0·7 +	0·65+	0·3 +	0·0	0·35−	0·55−	0·8 −	1·05−	1·3 −	1·5 −	1·5 −	1·45−	1·2 −	0·55−	0·15−	0·1 +	0·25+
2 fathoms	0·5 +	0·9 +	1·1 +	1·25+	1·35+	1·4 +	1·3 +	1·25+	1·2 +	1·2 +	1·0 +	0·6 +	0·2 +	0·15−	0·4 −	0·6 −	0·8 −	1·0 −	1·05−	1·0 −	0·8 −	0·45−	0·1 −	0·15+	0·35+	0·5 +
3 „	0·0	0·3 +	0·6 +	0·7 +	0·7 +	0·8 +	0·8 +	0·7 +	0·75+	0·75+	0·65+	0·5 +	0·25+	0·05−	0·3 −	0·45−	0·55−	0·55−	0·4 −	0·35−	0·25−	0·0	0·0	0·0	0·0	0·0

STATION E—RANGE II.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·55−	0·15+	0·6 +	0·9 +	1·1 +	1·1 +	1·7 +	1·8 +	1·5 +	1·15+	0·7 +	0·2 +	0·35−	0·8 −	1·15−	1·5 −	1·75−	1·95−	2·3 −	2·45−	2·3 −	1·9 −	1·6 −	1·25−	0·9 −	0·55−
1 fathom	0·15−	0·25+	0·8 +	1·15+	1·4 +	1·5 +	1·75+	1·8 +	1·55+	1·25+	0·85+	0·5 +	0·05+	0·45−	0·95−	1·35−	1·5 −	1·75−	2·0 −	2·1 −	2·0 −	1·7 −	1·4 −	0·95−	0·55−	0·15−
2 fathoms	0·15+	0·55+	0·9 +	1·1 +	1·15+	1·05+	1·25+	1·25+	1·3 +	1·3 +	1·1 +	0·75+	0·25+	0·1 −	0·55−	1·0 −	1·3 −	1·35−	1·45−	1·55−	1·35−	0·75−	0·45−	0·2 −	0·0	0·15+
3 „	—	—	—	0·7 +	0·6 +	0·5 +	0·9 +	0·9 +	0·95+	0·9 +	0·8 +	0·65+	0·4 +	0·0	0·5 −	0·85−	1·0 −	0·9 −	0·85−	1·0 −	0·65−	0·3 −	—	—	—	—
4 „	—	—	—	—	—	—	—	—	0·65+	0·65+	0·5 +	0·35+	0·05+	0·3 −	0·5 −	0·55−	—	—	—	—	—	—	—	—	—	—

STATION E—RANGE III.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·85−	0·4 −	0·35+	1·05+	1·5 +	1·5 +	1·6 +	1·65+	1·7 +	1·4 +	1·0 +	0·45+	0·15−	0·65−	1·15−	1·65−	2·25−	2·4 −	2·5 −	2·85−	2·9 −	2·25−	1·8 −	1·5 −	1·2 −	0·85−
1 fathom	0·1 −	0·5 +	1·05+	1·65+	1·9 +	1·9 +	1·9 +	1·9 +	1·95+	1·85+	1·35+	0·85+	0·25+	0·25−	0·9 −	1·5 −	1·75−	1·75−	2·0 −	2·4 −	2·35−	1·8 −	1·4 −	1·15−	0·75−	0·1 −
2 fathoms	0·45+	0·85+	1·15+	1·35+	1·5 +	1·55+	1·65+	1·7 +	1·75+	1·6 +	1·35+	1·0 +	0·6 +	0·0	0·75−	1·2 −	1·45−	1·6 −	1·9 −	2·15−	2·1 −	1·7 −	1·15−	0·55−	0·0	0·45+
3 „	—	—	—	0·8 +	1·0 +	1·25+	1·5 +	1·65+	1·6 +	1·5 +	1·2 +	0·8 +	0·45+	0·0	0·6 −	1·05−	1·3−	1·15−	1·2 −	1·15−	1·4 −	1·5 −	—	—	—	—
4 „	—	—	—	—	—	—	—	—	1·15+	1·15+	0·85+	0·6 +	0·4 +	0·0	0·6 −	0·85−	—	—	—	—	—	—	—	—	—	—

STATION E—RANGE IV.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	1·2 −	0·5 −	0·3 +	1·0 +	1·6 +	1·95+	2·2 +	2·4 +	2·5 +	2·15+	1·5 +	0·7 +	0·0	0·6 −	1·05−	1·5 −	2·0 −	2·3 −	2·4 −	2·8 −	3·35−	2·9 −	2·5 −	2·25−	1·85−	1·2 −
1 fathom	0·65−	0·1 +	0·8 +	1·55+	1·95+	2·1 +	2·1 +	2·35+	2·5 +	2·2 +	1·6 +	0·85+	0·15+	0·5 −	0·95−	1·4 −	1·85−	2·15−	2·3 −	2·6 −	3·0 −	2·6 −	2·05−	1·65−	1·3 −	0·65−
2 fathoms	0·3 +	0·6 +	0·9 +	1·3 +	1·6 +	1·7 +	1·75+	1·85+	1·85+	1·8 +	1·6 +	1·1 +	0·4 +	0·25−	0·75−	1·25−	1·7 −	2·0 −	2·1 −	2·4 −	2·65−	2·3 −	1·7 −	0·8 −	0·15−	0·25+
3 „	—	—	—	1·2 +	1·25+	1·3 +	1·4 +	1·6 +	1·65+	1·5 +	1·35+	1·1 +	0·55+	0·0	0·4 −	0·9 −	1·6 −	1·9 −	2·0 −	1·95−	1·6 −	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow: Flood + and Ebb −

STATION F—RANGE I.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·45−	0·25−	0·05+	0·35+	0·55+	0·65+	0·75+	0·75+	0·7 +	0·6 +	0·45+	0·2 +	0·0	0·3 −	0·75−	1·1 −	1·35−	1·55−	1·65−	1·7 −	1·6 −	1·55−	1·25−	0·95−	0·75−	0·45−
1 fathom	0·2 −	0·0	0·25+	0·5 +	0·7 +	0·8 +	1·0 +	1·05+	0·9 +	0·75+	0·6 +	0·35+	0·1 +	0·2 −	0·5 −	0·7 −	0·9 −	1·05−	1·15−	1·2 −	1·15−	0·9 −	0·65−	0·4 −	0·25−	0·2 −
2 fathoms	0·0	0·35+	0·65+	0·8 +	0·85+	0·9 +	0·85+	0·85+	0·9 +	0·85+	0·8 +	0·6 +	0·3 +	0·05−	0·35−	0·5 −	0·6 −	0·65−	0·7 −	0·65−	0·6 −	0·5 −	0·4 −	0·15−	0·05−	0·0
3 ,,	0·4 +	0·5 +	0·55+	0·55+	0·6 +	0·65+	0·6 +	0·55+	0·6 +	0·55+	0·5 +	0·3 +	0·1 +	0·0	0·15−	0·3 −	0·35−	0·45−	0·45−	0·4 −	0·3 −	0·15−	0·0	0·0	0·25+	0·35+
4 ,,	0·5 +	0·4 +	0·5 +	0·5 +	0·6 +	0·6 +	0·55+	0·45+	0·3 +	0·15+	0·15+	0·0	0·0	0·0	0·0	0·1 −	0·25−	0·25−	0·25−	0·25−	0·15−	0·05−	0·0	0·0	0·2 +	0·4 +
5 ,,	—	—	—	—	—	0·45+	0·4 +	0·35+	0·35+	0·2 +	0·1 +	0·0	0·0	0·0	0·0	0·0	0·05−	0·05−	0·05−	—	—	—	—	—	—	—

STATION F—RANGE II.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·7 −	0·35−	0·05+	0·35+	0·55+	0·95+	1·25+	1·05+	0·75+	0·55+	0·3 +	0·1 −	0·6 −	1·2 −	1·6 −	1·8 −	1·9 −	2·05−	2·15−	2·5 −	2·5 −	2·05−	1·6 −	1·25−	1·05−	0·7 −
1 fathom	0·35−	0·1 +	0·65+	0·95+	0·95+	1·05+	1·35+	1·35+	1·2 +	0·9 +	0·8 +	0·75+	0·4 +	0·25−	0·65−	1·05−	1·4 −	1·7 −	1·85−	1·8 −	1·75−	1·55−	1·25−	0·95−	0·65−	0·35−
2 fathoms	0·65+	0·7 +	0·8 +	1·05+	1·2 +	1·25+	1·2 +	1·05+	1·0 +	1·0 +	0·95+	0·85+	0·55+	0·15+	0·3 −	0·55−	0·85−	1·05−	1·15−	1·1 −	0·9 −	0·6 −	0·35−	0·0	0·4 +	0·65+
3 ,,	0·75+	0·9 +	0·95+	0·75+	0·75+	1·05+	1·0 +	0·75+	0·8 +	0·9 +	0·9 +	0·7 +	0·4 +	0·1 +	0·2 −	0·4 −	0·5 −	0·55−	0·5 −	0·5 −	0·4 −	0·35−	0·2 −	0·15+	0·45+	0·75+
4 ,,	—	—	—	—	—	—	0·75+	0·6 +	0·7 +	0·75+	0·6 +	0·5 +	0·4 +	0·3 +	0·1 −	0·3 −	0·35−	0·4 −	0·25−	—	—	—	—	—	—	—

STATION F—RANGE III.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·65−	0·15−	0·35+	0·8 +	1·2 +	1·4 +	1·45+	1·4 +	1·3 +	1·2 +	0·8 +	0·5 +	0·05+	0·6 −	1·2 −	1·8 −	2·2 −	2·45−	2·9 −	3·15−	3·05−	2·7 −	2·2 −	1·65−	1·15−	0·65−
1 fathom	0·3 −	0·2 +	0·65+	1·1 +	1·25+	1·35+	1·4 +	1·55+	1·55+	1·4 +	0·95+	0·45+	0·0	0·5 −	1·05−	1·6 −	2·0 −	2·2 −	2·4 −	2·6 −	2·4 −	1·9 −	1·5 −	1·05−	0·7 −	0·3 −
2 fathoms	0·25+	0·5 +	0·95+	1·3 +	1·5 +	1·55+	1·6 +	1·75+	1·7 +	1·45+	1·05+	0·65+	0·35+	0·15−	0·7 −	1·25−	1·6 −	1·7 −	1·8 −	2·0 −	1·8 −	1·0 −	0·6 −	0·3 −	0·0	0·25+
3 ,,	—	0·8 +	0·95+	1·0 +	1·05+	1·05+	1·1 +	1·1 +	1·05+	0·95+	0·8 +	0·65+	0·4 +	0·05+	0·5 −	0·95−	1·2 −	1·25−	1·35−	1·75−	1·5 −	0·6 −	0·3 −	0·0	—	—
4 ,,	—	—	—	—	—	0·85+	0·9 +	0·9 +	0·9 +	0·85+	0·75+	0·7 +	0·5 +	0·15−	0·6 −	0·85−	0·9 −	0·9 −	0·95−	—	—	—	—	—	—	—
5 ,,	—	—	—	—	—	—	1·15+	1·15+	1·1 +	1·1 +	0·8 +	0·65+	0·4 +	0·1 +	0·3 −	0·55−	0·65−	—	—	—	—	—	—	—	—	—

STATION F—RANGE IV.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	1·05−	0·3 −	0·4 +	0·9 +	1·35+	1·45+	1·45+	1·5 +	1·35+	1·0 +	0·7 +	0·4 +	0·5 −	0·75−	1·5 −	1·85−	2·1 −	2·35−	2·6 −	3·1 −	3·1 −	2·5 −	2·0 −	1·9 −	1·6 −	1·15−
1 fathom	0·4 −	0·15+	0·8 +	1·45+	1·65+	1·6 +	1·55+	1·7 +	1·7 +	1·45+	1·05+	0·6 +	0·05+	0·6 −	1·3 −	1·75−	1·8 −	1·95−	2·25−	2·6 −	2·55−	1·8 −	1·3 −	1·15−	0·9 −	0·4 −
2 fathoms	0·35+	0·95+	1·45+	1·5 +	1·5 +	1·6 +	1·75+	2·0 +	1·95+	1·65+	1·25+	0·65+	0·15+	0·4 −	0·95−	1·5 −	1·65−	1·7 −	2·0 −	2·25−	2·1 −	1·3 −	0·75−	0·65−	0·3 −	0·35+
3 ,,	0·35+	0·75+	1·0 +	1·05+	1·0 +	1·4 +	1·7 +	1·95+	1·8 +	1·55+	1·15+	0·65+	0·25+	0·15−	0·8 −	1·15−	1·2 −	1·35−	1·5 −	1·6 −	1·65−	1·1 −	0·4 −	0·2 −	0·0	0·35+
4 ,,	—	—	—	0·8 +	0·9 +	1·05+	1·35+	1·6 +	1·6 +	1·3 +	0·9 +	0·55+	0·2 +	0·2 −	0·6 −	1·0 −	1·05−	1·0 −	1·1 −	1·2 −	1·1 −	0·6 −	—	—	—	—
5 ,,	—	—	—	—	—	—	1·0 +	1·25+	1·25+	1·1 +	0·8 +	0·5 +	0·2 +	0·1 −	0·3 −	0·5 −	0·55−	0·7 −	0·65−	0·5 −	—	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow : Flood + and Ebb —

STATION G—RANGE II.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·45—	0·05+	0·45+	0·7 +	0·8 +	0·85+	0·75+	0·45+	0·05+	0·3 —	0·45—	0·55—	0·65—	0·7 —	0·85—	1·0 —	1·2 —	1·45—	1·8 —	1·95—	1·85—	1·75—	1·4 —	1·05—	0·75—	0·45—
1 fathom	0·0	0·45+	0·55+	0·75+	0·9 +	1·0 +	0·95+	0·8 +	0·55+	0·2 +	0·05—	0·25—	0·4 —	0·55—	0·6 —	0·8 —	0·9 —	1·25—	1·4 —	1·35—	1·15—	1·0 —	0·75—	0·5 —	0·4 —	0·2 —
2 fathoms	0·3 +	0·65+	0·8 +	0·95+	1·05+	1·05+	1·15+	0·95+	0·85+	0·60+	0·4 +	0·1 +	0·15—	0·35—	0·5 —	0·55—	0·6 —	0·75—	0·85—	0·85—	0·65—	0·4 —	0·35—	0·25—	0·0	0·3 +
3 „	0·45+	0·6 +	0·75+	0·8 +	0·8 +	0·75+	0·8 +	0·9 +	0·95+	0·75+	0·5 +	0·2 +	0·1 —	0·2 —	0·25—	0·35—	0·4 —	0·5 —	0·6 —	0·5 —	0·4 —	0·3 —	0·25—	0·2 —	0·1 —	0·45+
4 „	—	—	—	0·55+	0·6 +	0·5 +	0·65+	0·8 +	1·0 +	0·8 +	0·6 +	0·4 +	0·2 +	0·0	0·2 —	0·3 —	0·35—	0·35—	0·4 —	0·35—	0·25—	—	—	—	—	—
5 „	—	—	—	—	—	—	0·35+	0·7 +	0·75+	0·6 +	0·45+	0·3 +	0·1 +	0·0	0·05—	0·3 —	0·35—	0·3 —	0·3 —	—	—	—	—	—	—	—

STATION G—RANGE III.

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·5 —	0·2 —	0·1 +	0·3 +	0·5 +	0·7 +	0·9 +	0·95+	0·85+	0·5 +	0·0	0·55—	0·85—	1·05—	1·25—	1·5 —	1·75—	1·9 —	2·15—	2·2 —	2·2 —	2·1 —	1·8 —	1·3 —	0·85—	0·35—
1 fathom	0·3 —	0·05+	0·35+	0·55+	0·7 +	0·75+	0·95+	1·1 +	1·0 +	0·65+	0·15+	0·3 —	0·65—	0·9 —	1·0 —	0·95—	0·95—	1·0 —	1·15—	1·35—	1·4 —	1·35—	1·15—	0·9 —	0·45—	0·0
2 fathoms	0·0	0·5 +	0·9 +	1·2 +	1·2 +	1·4 +	1·55+	1·6 +	1·3 +	0·85+	0·6 +	0·45+	0·25+	0·05—	0·4 —	0·7 —	0·75—	0·65—	0·7 —	0·95—	1·05—	0·9 —	0·65—	0·45—	0·15—	0·25+
3 „	0·45+	0·8 +	1·05+	1·05+	1·0 +	1·05+	1·15+	1·25+	1·2 +	1·1 +	0·95+	0·75+	0·4 +	0·1 +	0·25—	0·4 —	0·45—	0·5 —	0·6 —	0·8 —	0·65—	0·45—	0·35—	0·25—	0·15+	0·35+
4 „	—	—	—	—	0·75+	0·85+	1·0 +	1·1 +	1·15+	1·15+	1·0 +	0·8 +	0·5 +	0·15+	0·15—	0·3 —	0·25—	0·35—	0·5 —	0·65—	—	—	—	—	—	—
5 „	—	—	—	—	—	—	—	—	1·1 +	1·0 +	0·9 +	0·65+	0·35+	0·05+	0·10—	0·2 —	0·15—	—	—	—	—	—	—	—	—	—

STATION G—RANGE IV

Time in Hours :	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·7 —	0·35—	0·45+	1·05+	1·4 +	1·6 +	1·6 +	1·6 +	1·5 +	1·2 +	0·9 +	0·5 +	0·3 —	1·1 —	1·7 —	2·1 —	2·35—	2·55—	2·7 —	2·95—	3·0 —	2·5 —	2·25—	1·7 —	1·05—	0·7 —
1 fathom	0·35—	0·35+	0·8 +	1·15+	1·55+	1·70+	1·75+	1·75+	1·55+	1·3 +	0·9 +	0·3 +	0·3 —	0·8 —	1·1 —	1·25—	1·35—	1·4 —	1·55—	1·7 —	1·65—	1·45—	1·2 —	1·0 —	0·7 —	0·35—
2 fathoms	0·45+	1·0 +	1·55+	1·75+	1·8 +	1·8 +	1·85+	1·85+	1·65+	1·35+	1·0 +	0·55+	0·0	0·55—	0·85—	1·0 —	1·0 —	1·05—	1·25—	1·5 —	1·4 —	1·0 —	0·75—	0·5 —	0·2 —	0·45+
3 „	0·35+	0·9 +	1·2 +	1·5 +	1·45+	1·15+	1·35+	1·55+	1·5 +	1·4 +	1·15+	0·85+	0·3 +	0·25—	0·45—	0·5 —	0·55—	0·7 —	0·9 —	1·1 —	1·0 —	0·6 —	0·45—	0·3 —	0·05—	0·35—
4 „	—	—	—	—	—	—	1·15+	1·35+	1·45+	1·45+	1·2 +	0·95+	0·4 +	0·15—	0·4 —	0·45—	0·5 —	0·4 —	0·35—	—	—	—	—	—	—	—
5 „	—	—	—	—	—	—	—	—	1·25+	1·2 +	1·1 +	0·7 +	0·25+	0·1 —	0·35—	0·35—	0·3 —	—	—	—	—	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow: Flood + and Ebb −

STATION H—RANGE I.

Time in hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·45−	0·15+	0·5 +	0·55+	0·75+	0·8 +	0·8 +	1·05+	1·05+	0·5 +	0·2 +	0·1 +	0·4 −	0·75−	0·9 −	1·1 −	1·3 −	1·6 −	1·65−	1·75−	1·55−	1·5 −	1·4 −	1·1 −	0·65−	0·45−
1 fathom	0·1 −	0·15+	0·25+	0·25+	0·5 +	0·55+	0·55+	0·9 +	0·85+	0·7 +	0·6 +	0·3 +	0·1 +	0·1 −	0·3 −	0·45−	0·65−	0·85−	0·9 −	0·95−	0·95−	0·8 −	0·6 −	0·35−	0·1 −	0·0
2 fathoms	0·0	0·1 +	0·25+	0·45+	0·6 +	0·7 +	0·7 +	0·8 +	0·85+	0·65+	0·6 +	0·4 +	0·15+	0·05−	0·25−	0·3 −	0·3 −	0·4 −	0·5 −	0·5 −	0·5 −	0·3 −	0·1 −	0·0	0·0	0·0
3 „	—	—	—	0·0	0·25+	0·4 +	0·4 +	0·6 +	0·7 +	0·65+	0·5 +	0·25+	0·0	0·0	0·15−	0·25−	0·35−	0·4 −	0·4 −	0·2 −	0·0	—	—	—	—	—
4 „	current at 4 fathoms slack throughout.																									

STATION H—RANGE II.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·55−	0·15−	0·25+	0·85+	1·05+	1·3 +	1·35+	1·25+	1·05+	0·85+	0·5 +	0·1 +	0·35−	0·75−	1·0 −	1·35−	1·65−	1·95−	2·1 −	2·1 −	1·95−	1·7 −	1·5 −	1·15−	0·75−	0·4 −
1 fathom	0·2 −	0·25+	0·8 +	1·0 +	1·25+	1·5 +	1·5 +	1·4 +	1·25+	1·0 +	0·65+	0·3 +	0·0	0·3 −	0·6 −	0·9 −	1·25−	1·55−	1·6 −	1·65−	1·5 −	1·3 −	1·05−	0·7 −	0·5 −	0·0
2 fathoms	0·35+	0·75+	1·0 +	1·05+	1·3 +	1·45+	1·5 +	1·5 +	1·35+	1·15+	0·8 +	0·55+	0·2 +	0·15−	0·5 −	0·8 −	1·15−	1·4 −	1·5 −	1·55−	1·45−	1·15−	0·8 −	0·0	0·0	0·25+
3 „	0·45+	0·65+	0·8 +	0·95+	1·1+	1·2 +	1·25+	1·25+	1·2 +	0·95+	0·75+	0·55+	0·35+	0·05+	0·35−	0·6 −	0·85−	1·05−	1·15−	1·1 −	0·95−	0·65−	0·25−	0·0	0·0	0·3 +
4 „	—	—	—	—	—	1·15+	1·2 +	1·2 +	1·05+	0·85+	0·7 +	0·5 +	0·3 +	0·15+	0·05−	0·25−	0·5 −	0·7 −	0·75−	0·7 −	0·45−	—	—	—	—	—

STATION H—RANGE III.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·6 −	0·05−	0·3 +	0·65+	0·85+	0·9 +	1·1 +	1·15+	1·15+	1·1 +	0·85+	0·55+	0·2 +	0·3 −	0·9 −	1·65−	2·35−	2·4 −	2·3 −	2·55	2·4 −	2·1 −	1·9 −	1·65−	1·2 −	0·6 −
1 fathom	0·0	0·8 +	1·3 +	1·45+	1·5 +	1·6 +	1·75+	1·7 +	1·55+	1·35+	1·05+	0·7 +	0·3 +	0·1 −	0·4 −	0·55−	0·85−	1·35−	1·4 −	1·5 −	1·8 −	1·7 −	1·3 −	1·0 −	0·6 −	0·0
2 fathoms	0·65+	1·1 +	1·25+	1·3 +	1·4 +	1·5 +	1·6 +	1·6 +	1·45+	1·25+	1·0 +	0·75+	0·45+	0·15−	0·0	0·15−	0·35−	0·7 −	1·25−	1·75−	1·75−	1·2 −	0·7 −	0·3 −	0·0	0·65+
3 „	0·55+	0·7 +	0·85+	0·95+	1·05+	1·2 +	1·4 +	1·55+	1·6 +	1·4 +	1·1 +	0·8 +	0·5 +	0·25+	0·0	0·15−	0·3 −	0·6 −	0·9 −	1·65−	1·25−	0·85−	0·4 −	0·25−	0·0	0·55+
4 „	—	—	—	—	—	—	1·15+	1·3 +	1·3 +	1·15+	0·95+	0·7 +	0·5 +	0·25+	0·1 +	0·05−	0·15−	0·4 −	0·7 −	0·85−	0·6 −	—	—	—	—	—
5 „	—	—	—	—	—	—	—	—	—	0·9 +	0·75+	0·35+	0·0	0·0	0·0	0·0	0·0	—	—	—	—	—	—	—	—	—

STATION H—RANGE IV.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	1·1 −	0·0	0·7 +	1·3 +	1·75+	2·15+	2·2 +	2·3 +	2·1 +	1·8 +	1·55+	1·15+	0·1 +	1·1 −	1·45−	1·65−	2·3 −	2·8 −	3·0 −	3·25−	3·5 −	2·95−	2·5 −	2·2 −	1·7 −	1·1 −
1 fathom	0·0	0·7 +	1·0 +	1·7 +	1·95+	2·0 +	2·0 +	2·3 +	2·3 +	1·95+	1·7 +	1·4 +	0·7 +	0·2 +	0·3 −	0·8 −	1·4 −	2·0 −	2·35−	2·75−	2·8 −	2·2 −	1·8 −	1·45−	0·85−	0·0
2 „	0·65+	0·95+	1·1 +	1·6 +	1·8 +	1·9 +	2·1 +	2·4 +	2·35+	2·05+	1·6 +	1·25+	0·8 +	0·45+	0·05+	0·35−	0·9 −	1·6 −	2·2 −	2·6 −	2·5 −	1·6 −	1·2 −	0·8 −	0·2 −	0·65+
3 „	—	0·65+	0·65+	1·2 +	1·3 +	1·75+	1·9 +	2·25+	2·2 +	1·9 +	1·5 +	1·2 +	0·75+	0·4 +	0·0	0·3 −	0·75−	1·3 −	1·9 −	2·15−	1·6 −	0·75−	0·6 −	0·4 −	—	—
4 „	—	—	—	—	1·1 +	1·45+	1·65+	1·9 +	2·0 +	1·85+	1·6 +	1·3 +	0·75+	0·35+	0·0	0·2 −	0·6 −	1·0 −	1·35−	1·4 −	1·1 −	—	—	—	—	—
5 „	—	—	—	—	—	—	—	—	1·6 +	1·4 +	1·1 +	0·8 +	0·45+	0·1 +	0·15−	0·2 −	0·35−	—	—	—	—	—	—	—	—	—

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow: Flood + and Ebb −

STATION I—RANGE I.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	—	—	—	—	—	—	—	—	—	—	—	—	0·0	0·6 −	0·9 −	1·05−	1·35−	1·6 −	1·85−	1·95−	1·55−	1·25−	1·1 −	1·0 −	0·95−	0·6 −
1 fathom	—	—	—	—	—	—	—	—	—	—	—	—	0·0	0·3 −	0·45−	0·85−	1·15−	1·5 −	1·55−	1·4 −	1·3 −	1·0 −	0·55−	0·4 −	0·1 −	0·1 +
2 fathoms	—	—	—	—	—	—	—	—	—	—	—	—	0·0	0·25−	0·35−	0·75−	0·95−	1·25−	1·45−	1·3 −	1·05−	0·7 −	0·35−	0·3 −	0·0	0·3 +
3 ,,	—	—	—	—	—	—	—	—	—	—	—	—	0·0	0·2 −	0·35−	0·65−	0·85−	1·15−	1·4 −	1·2 −	0·8 −	0·55−	0·3 −	0·2 −	0·3 +	0·55+
4 ,,	—	—	—	—	—	—	—	—	—	—	—	—	0·0	0·2 −	0·3 −	0·5 −	0·7 −	0·95−	1·1 −	1·05−	0·7 −	0·45−	0·25−	0·05+	0·45+	0·65+
5 ,,	—	—	—	—	—	—	—	—	—	—	—	—	0 0	0·0	0·25−	0·35−	0·4 −	0·65−	0·95−	0·75−	0·4 −	—	—	—	—	—

STATION I—RANGE II.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·3 −	0·0	0·4 +	0·9 +	1·9 +	2·7 +	2·4 +	2·05+	1·8 +	1·25+	1·15+	0·8 +	0·55+	—	—	—	—	—	—	—	—	—	—	—	—	—
1 fathom	0·15−	0·35+	0·6 +	1·0 +	2·0 +	2·45+	2·55+	2·1 +	1·75+	1·2 +	1·1 +	0·8 +	0·5 +	—	—	—	—	—	—	—	—	—	—	—	—	—
2 fathoms	0·0	0·5 +	0·95+	1·4 +	2·0 +	2·35+	2·5 +	2·25+	1·85+	1·3 +	1·15+	0·8 +	0·6 +	—	—	—	—	—	—	—	—	—	—	—	—	—
3 ,,	0·0	0·45+	0·9 +	1·25+	1·55+	2·0 +	2·45+	2·4 +	2·05+	1·3 +	1·1 +	0·75+	0·5 +	—	—	—	—	—	—	—	—	—	—	—	—	—
4 ,,	0·15+	0·40+	0·7 +	1·1 +	1·5 +	1·9 +	2·4 +	2·35+	1·9 +	1·4 +	0·8 +	0·55+	0·3 +	—	—	—	—	—	—	—	—	—	—	—	—	—
5 ,,	0·2 +	0·3 +	0·5 +	0·85+	1·35+	1·85+	2·05+	2·05+	1·7 +	1·1 +	0·7 +	0·5 +	0·2 +	—	—	—	—	—	—	—	—	—	—	—	—	—

STATION I—RANGE III.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·45−	0·0	0·35+	0·7 +	1·25+	2·25+	2·65+	2·9 +	3·0 +	2·35+	1·55+	0·75+	0·2 +	0·35−	0·75−	1·3 −	1·95−	2·6 −	3·05−	3·35−	3·2 −	2·35−	1·8 −	1·4 −	0·85−	0·45−
1 fathom	0·15−	0·3 +	0·7 +	1·1 +	1·75+	2·15+	2·65+	2·95+	2·85+	2·2 +	1·55+	0·85+	0·25+	0·2 −	0·7 −	1·2 −	1·8 −	2·35−	2·85−	2·95−	2·5 −	1·8 −	1·2 −	0·65−	0·25−	0·15−
2 fathoms	0·0	0·5 +	0·95+	1·3 +	1·85+	2·3 +	2·8 +	2·95+	2·75+	2·15+	1·5 +	0·95+	0·4 +	0·15−	0·6 −	1·1 −	1·7 −	2·25−	2·75−	2·8 −	2·2 −	1·45−	0·85−	0·35−	0·1 −	0·0
3 ,,	0·3 +	0·65+	1·0 +	1·2 +	1·6 +	2·1 +	2·75+	2·8+	2·55+	2·1 +	1·45+	1·0 +	0·4 +	0·15−	0·6 −	1·1 −	1·7 −	2·15−	2·65−	2·55−	2·0 −	1·35−	0·65−	0·15−	0·05+	0·3 +
4 ,,	0·25+	0·55+	0·75+	0·9 +	1·25+	1·85+	2·6 +	2·6 +	2·25+	1·85+	1·4 +	1·0 +	0·4 +	0·0	0·45−	1·0 −	1·55−	2·15−	2·55−	2·4 −	1·7 −	1·0 −	0·45−	0·05−	0·15+	0·25+
5 ,,	—	—	0·05+	0·5 +	0·8 +	1·45+	2·4 +	2·4 +	2·1 +	1·65+	1·3 +	1·0 +	0·5 +	0·05+	0·35−	0·9 −	1·5 −	2·05−	2·2 −	1·9 −	1·4 −	0·65−	0·0	—	—	—
6 ,,	—	—	—	—	—	—	—	—	—	1·55+	0·9 +	0·5 +	0·3 +	0·1 +	0·25−	0·8 −	—	—	—	—	—	—	—	—	—	—

STATION I—RANGE IV.

Time in Hours:	Before High Water												High Water	After High Water											
	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·6 −	0·3 +	0·7 +	0·95+	1·9 +	3·2 +	3·7 +	3·8 +	3·6 +	3·0 +	2·1 +	1·2 +	0·05+	0·9 −	1·65−	2·3 −	2·9 −	3·45−	3·8 −	3·85−	3·45−	2·7 −	2·3 −	2·0 −	1·5 −	0·6 −
1 fathom	0·1 −	0·6 +	1·05+	1·6 +	2·2 +	3·2 +	3·95+	3·85+	3·3 +	2·65+	1·95+	1·05+	0·15+	0·75−	1·4 −	1·95−	2·4 −	2·75−	3·15−	3·3 −	2·9 −	2·25−	1·7 −	1·25−	0·75−	0·1 −
2 fathoms	0·2 +	0·8 +	1·25+	1·65+	2·2 +	3·15+	4·0 +	3·9 +	3·35+	2·7 +	1·95+	1·05+	0·15+	0·7 −	1·3 −	1·75−	2·3 −	2·65−	2·85−	2·9 −	2·2 −	1·5 −	1·0 −	0·65−	0·35−	0·2 +
3 ,,	0·35+	0·8 +	1·05+	1·25+	1·7 +	3·0 +	4·25+	4·1 +	3·25+	2·5 +	1·8 +	1·0 +	0·15+	0·65−	1·25−	1·8 −	2·2 −	2·6 −	2·75−	2·65−	1·7 −	0·9 −	0·5 −	0·25−	0·0	0·35+
4 ,,	0·4 +	0·7 +	0·9 +	1·15+	1·65+	2·9 +	4·4 +	4·3 +	3 45+	2·7 +	1·95+	1·0 +	0·15+	0·6 −	1·15−	1·65−	2·05−	2·4 −	2·55−	2·35−	1·15−	0·5 −	0·25−	0·05−	0·1 +	0·4 +
5 ,,	—	—	—	1·0 +	1·5 +	2·7 +	4·3 +	4·3 +	3·4 +	2·7 +	1·95+	1·0 +	0·15+	0·55−	1·1 −	1·6 −	2·0 −	2·2 −	2·05−	1·9 −	0·8 −	0·3 −	0·05−	0·0	0·2 +	0·45+

TABLE 1—*Speed in Feet per Second of Current in Centre of River every Half-hour and at Intervals in Depth of One Fathom—continued.*

Direction of Flow : Flood + and Ebb —

STATION K—RANGE I.

	Before High Water												High Water	After High Water											
Time in Hours :	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·5 −	0·35−	0·3 −	0·45+	1·1 +	1·65+	1·7 +	1·3 +	1·2 +	1·3 +	1·2 +	0·45+	0·3 −	0·8 −	1·1 −	1·5 −	1·9 −	2·2 −	2·3 −	2·2 −	1·8 −	1·45−	0·95−	0·75−	0·6 −	0·45−
1 fathom	0·2 −	0·0	0·1 +	0·3 +	0·95+	1·7 +	1·6 +	1·25+	1·4 +	0·9 +	0·7 +	0·6 +	0·35+	0·4 −	0·9 −	1·6 −	2·1 −	2·1 −	2·05−	2·0 −	1·5 −	1·15−	0·65−	0·55−	0·5 −	0·2 −
2 fathoms	0·0	0·1 +	0·4 +	0·8 +	1·35+	1·85+	1·5 +	1·5 +	1·3 +	0·9 +	0·8 +	0·7 +	0·3 +	0·25−	0·75−	1·4 −	1·7 −	2·0 −	2·1 −	1·6 −	1·2 −	0·85−	0·45−	0·15−	0·0	0·0
3 ,, ...	0·2 +	0·25+	0·5 +	0·95+	1·5 +	1·9 +	1·7 +	1·3 +	1·1 +	1·0 +	0·9 +	0·45+	0·2 +	0·4 −	1·0 −	1·6 −	1·55−	1·75−	1·85−	1·55−	1·15−	0·75−	0·35−	0·05−	0·05+	0·2 +
4 ,, ...	0·3 +	0·5 +	0·7 +	1·05+	1·5 +	1·9 +	1·85+	1·7 +	1·55+	1·25+	0·95+	0·65+	0·4 +	0·05−	0·7 −	1·6 −	1·7 −	1·75−	1·8 −	1·35−	1·05−	0·7 −	0·3 −	0·05−	0·1 +	0·3 +
5 ,, ...	0·35+	0·6 +	0·85+	1·2 +	1·65+	1·9 +	1·9 +	1·6 +	1·45+	1·2 +	1·0 +	0·85+	0·45+	0·0	0·6 −	1·3 −	1·4 −	1·6 −	1·65−	1·2 −	0·85−	0·6 −	0·25−	0·0	0·15+	0·35+
6 ,, ...	0·55+	0·75+	0·8 +	1·4 +	1·85+	1·8 +	1·95+	1·65+	1·5 +	1·2 +	1·0 +	0·8 +	0·4 +	0·15+	0·7 −	1·25−	1·45−	1·65−	1·55−	1·05−	0·65−	0·4 −	0·0	0·05+	0·3 +	0·55+

STATION K—RANGE IV.

	Before High Water												High Water	After High Water											
Time in Hours :	6	5·5	5	4·5	4	3·5	3	2·5	2	1·5	1	0·5		0·5	1	1·5	2	2·5	3	3·5	4	4·5	5	5·5	6	6·5
Surface	0·7 −	0·1 +	1·0 +	2·1 +	3·0 +	4·1 +	4·9 +	5·0 +	4·8 +	4·0 +	2·8 +	1·7 +	0·1 −	1·3 −	2·5 −	3·6 −	4·2 −	4·6 −	4·9 −	4·4 −	3·4 −	2·5 −	2·1 −	1·8 −	1·4 −	0·9 −
1 fathom	0·7 −	0·0	0·8 +	1·7 +	2·6 +	3·8 +	4·8 +	5·0 +	4·9 +	3·7 +	2·5 +	1·3 +	0·0	1·3 −	2·4 −	3·3 −	4·0 −	4·5 −	4·6 −	4·3 −	3·1 −	2·3 −	1·9 −	1·6 −	1·3 −	0·9 −
2 fathoms	0·6 −	0·1 +	0·8 +	1·8 +	3·0 +	4·1 +	4·9 +	5·1 +	5·0 +	4·1 +	2·9 +	1·5 +	0·0	1·5 −	2·5 −	3·5 −	3·9 −	4·2 −	4·3 −	3·8 −	2·8 −	2·1 −	1·6 −	1·2 −	0·9 −	0·6 −
3 ,, ...	0·0	0·7 +	1·5 +	2·2 +	3·0 +	3·8 +	4·6 +	5·0 +	4·9 +	4·0 +	2·8 +	1·5 +	0·1 −	1·0 −	2·1 −	3·0 −	3·8 −	4·2 −	4·2 −	3·7 −	3·0 −	2·2 −	1·5 −	0·9 −	0·5 −	0·1 −
4 ,, ...	0·3 +	0·9 +	1·5 +	2·2 +	2·9 +	3·8 +	4·7 +	4·9 +	4·8 +	4·0 +	2·9 +	1·6 +	0·1 −	1·1 −	2·2 −	3·1 −	3·6 −	3·8 −	3·7 −	3·2 −	2·5 −	1·7 −	1·0 −	0·4 −	0·1 −	0·1 +
5 ,, ...	0·1 +	0·5 +	1·2 +	2·0 +	2·8 +	3·5 +	4·2 +	4·5 +	4·5 +	4·0 +	2·9 +	1·6 +	0·1 −	1·1 −	2·2 −	3·0 −	3·6 −	3·8 −	3·7 −	3·3 −	2·5 −	1·7 −	1·0 −	0·6 −	0·3 −	0·0
6 ,, ...	0·1 +	0·6 +	1·2 +	2·0 +	2·8 +	3·6 +	3·9 +	4·1 +	4·1 +	3·6 +	2·6 +	1·5 +	0·1 −	0·9 −	2·0 −	2·8 −	3·4 −	3·6 −	3·5 −	3·1 −	2·6 −	2·0 −	1·4 −	0·7 −	0·3 −	0·0
7 ,, ...	0·0	0·4 +	1·0 +	1·8 +	2·4 +	3·0 +	3·4 +	3·6 +	3·6 +	3·4 +	2·7 +	1·8 +	0·1 −	1·2 −	2·4 −	3·1 −	3·4 −	3·5 −	3·3 −	3·0 −	2·4 −	1·8 −	1·0 −	0·5 −	0·2 −	0·0
8 ,, ...	—	—	—	—	—	—	—	—	—	3·0 +	2·4 +	1·7 +	0·2 −	0·9 −	1·9 −	2·7 −	3·0 −	—	—	—	—	—	—	—	—	—

NOTE.—The observations on Range IV at Station K were obtained by H.M. Surveying Ship " Fitzroy " during September, 1930.

TABLE 2—*Ratio of Average Speed of Whole Cross Section of River to Average Speed in the Centre of the River*

Figures denote Ratios of Speeds and Letters denote Stations in River

Hours before or after High Water.	Range of Tide.			
	I	II	III	IV
5B	0·87F	0·79F	0·78F	0·70F
4B	0·89F	0·84F	0·80F	0·68D, 0·70D, 0·73F
2·5B	—	—	0·81F	—
3B	0·91F	0·81F	0·80F	0·76F
2·5B	—	0·85F	—	—
2B	0·91F	0·87F	0·83F	0·80F, 0·68D
1B	0·83F	0·78F	0·73F	0·70F
H.W.	—	—	—	—
1A	0·71F	0·71F	0·71F	0·70F
1·25A	—	—	—	0·62F
2A	0·76F	0·78F, 0·66D	0·74F	0·87H, 0·70F
3A	0·89F	0·84D, 0·86F	0·83F	0·80H, 0·73F
3·5A	0·84F	—	—	—
4A	0·91F	0·85F	0·83F	0·77F, 0·79H
4·5A	—	—	—	0·80B
5A	0·90F	0·84F	0·81F	0·80F

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour*

Direction of Flow : Flood + and Ebb —

STATION A—RANGE II.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·08+	0·84+	1·37+	1·32+	1·38+	0·73+	0·26—	1·36—	1·57—	1·72—	1·54—	0·94—	0·55—
1–2 fathoms	0·51+	1·26+	1·57+	1·39+	1·43+	0·99+	0·08—	1·18—	1·56—	1·62—	1·44—	0·89—	0·41—
2–3 ,,	0·5 +	1·0 +	1·3 +	1·2 +	1·06+	0·77+	0·04—	0·90—	1·2 —	1·2 —	1·0 —	0·6 —	0·2 —
3–4 ,,	—	0·3 +	0·5 +	0·5 +	0·5 +	0·3 +	0·0	0·6 —	0·7 —	0·6 —	0·5 —	—	—
4–5 ,,	—	—	—	—	0·3 +	0·2 +	0·0	0·3 —	—	—	—	—	—

STATION B—RANGE I.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·07—	0·58+	0·89+	1·11+	0·80+	0·34+	0·22—	0·79—	1·29—	1·41—	1·30—	1·11—	0·76—
1–2 fathoms	0·34+	0·73+	1·09+	1·39+	1·11+	0·54+	0·34—	0·94—	1·22—	1·11—	0·86—	0·65—	0·35—
2–3 ,,	0·2 +	0·4 +	0·6 +	0·95+	0·84+	0·44+	0·33—	0·70—	0·80—	0·6 —	0·5 —	0·3 —	0·2 —
3–4 ,,	—	—	—	0·3 +	0·3 +	0·2 +	0·2 —	0·4 —	0·2 —	0·1 —	—	—	—
4–5 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—

STATION B—RANGE III.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·11—	0·69+	1·35+	1·61+	1·74+	0·78+	0·52—	1·66—	2·06—	2·04—	2·16—	1·55—	0·77—
1–2 fathoms	0·57+	1·32+	1·78+	1·86+	1·80+	1·12+	0·14—	1·17—	1·55—	1·67—	1·62—	0·81—	0·04—
2–3 ,,	0·2 +	0·5 +	1·1 +	1·62+	1·58+	1·21+	0·04+	0·66—	0·87—	0·8 —	0·4 —	0·2 —	—
3–4 ,,	—	—	—	0·4 +	0·8 +	0·7 +	0·0	0·3 —	0·3 —	—	—	—	—
4–5 ,,	—	—	—	—	—	0·0	0·0	—	—	—	—	—	—

STATION B—RANGE IV.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·66—	0·60+	1·50+	2·37+	2·58+	1·31+	0·28—	1·83—	2·43—	2·61—	2·55—	1·92—	1·32—
1–2 fathoms	0·2 +	0·87+	1·59+	2·53+	2·72+	1·64+	0·15+	1·34—	1·93—	2·20—	2·09—	1·57—	0·8 —
2–3 ,,	—	0·2 +	0·5 +	2·0 +	2·32+	1·50+	0·26+	0·90—	1·24—	1·42—	0·3 —	—	—
3–4 ,,	—	—	—	0·7 +	1·5 +	1·06+	0·21+	0·57—	0·4 —	—	—	—	—
4–5 ,,	—	—	—	—	0·2 +	0·2 +	0·1 +	0·0	—	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow: Flood + and Ebb −

STATION C—RANGE I.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·18−	0·70+	1·46+	1·38+	0·81+	0·0 +	0·81−	1·62−	2·20−	2·15−	1·88−	1·45−	0·95−
1–2 fathoms	0·48+	1·30+	1·87+	1·71+	1·16+	0·50+	0·24−	1·06−	1·60−	1·48−	1·18−	0·72−	0·16−
2–3 ,,	0·1 +	0·4 +	1·70+	1·62+	1·27+	0·78+	0·12−	0·76−	0·98−	0·71−	0·5 −	0·3 −	0·0
3–4 ,,	—	—	0·3 +	0·3 +	0·5 +	0·4 +	0·0	0·2 −	0·2 −	0·2 −	—	—	—
4–5 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—

STATION C—RANGE II.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·03−	1·10+	1·61+	1·56+	1·14+	0·34+	0·69−	1·90−	2·63−	2·94−	2·49−	1·64−	1·10−
1–2 fathoms	0·59+	1·50+	1·77+	1·71+	1·39+	0·80+	0·19−	1·28−	1·90−	2·11−	1·73−	0·94−	0·40−
2–3 ,,	0·1 +	0·2 +	1·64+	1·58+	1·33+	0·84+	0·04+	0·75−	0·93−	0·88−	0·2 −	0·1 −	—
3–4 ,,	—	—	0·5 +	0·4 +	0·7 +	0·3 +	0·0	0·4 −	0·3 −	0·4 −	—	—	—
4–5 ,,	—	—	—	—	—	—	—	—	—	—	—	—	—

STATION C—RANGE III.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·26−	0·93+	1·70+	2·25+	1·82+	0·57+	0·87−	2·13−	2·67−	2·90−	2·89−	2·00−	1·11−
1–2 fathoms	0·84+	1·73+	2·12+	2·65+	2·15+	0·94+	0·18−	1·57−	2·10−	2·45−	2·36−	1·33−	0·28−
2–3 ,,	0·4 +	1·98+	2·12+	2·54+	2·12+	0·99+	0·16−	1·28−	1·41−	1·64−	1·0 −	0·4 −	—
3–4 ,,	—	—	—	1·5 +	1·6 +	1·0 +	0·0	0·7 −	0·4 −	0·4 −	—	—	—
4–5 ,,	—	—	—	—	—	0·5 +	0·0	—	—	—	—	—	—

STATION C—RANGE IV.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·32−	1·84+	2·41+	2·83+	2·56+	1·34+	0·53−	2·51−	3·09−	3·88−	3·58−	2·48−	1·74−
1–2 fathoms	0·06−	1·70+	2·60+	3·31+	2·89+	1·62+	0·13−	1·96−	2·71−	3·39−	2·89−	1·94−	1·40−
2–3 ,,	—	0·5 +	2·27+	3·34+	2·85+	1·63+	0·0	1·54−	2·23−	2·74−	2·32−	0·5 −	—
3–4 ,,	—	—	—	2·78+	2·52+	1·44+	0·03−	1·21−	1·55−	0·5 −	—	—	—
4–5 ,,	—	—	—	—	1·0 +	1·0 +	0·0	0·6 −	—	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow : Flood + and Ebb —

STATION D—RANGE I.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·09–	0·05+	0·39+	0·59+	0·36+	0·09–	0·47–	0·99–	1·58–	1·66–	1·51–	0·96–	0·55–
1–2 fathoms	0·62+	0·98+	1·21+	1·11+	0·87+	0·51+	0·04–	0·71–	1·03–	0·98–	0·78–	0·40–	0·03–
2–3 ,, ...	0·6 +	1·00+	1·17+	1·17+	1·02+	0·66+	0·07+	0·45–	0·58–	0·42–	0·4 –	0·3 –	0·1 +
3–4 ,, ...	0·2 +	0·5 +	0·6 +	0·8 +	0·7 +	0·6 +	0·1 +	0·3 –	0·4 –	0·2 –	0·2 –	0·1 –	0·0
4–5 ,, ...	—	—	—	—	0·2 +	0·2 +	0·0	0·0	—	—	—	—	—

STATION D—RANGE II.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·21–	0·63+	1·23+	1·48+	1·07+	0·18+	0·80–	1·58–	2·05–	2·24–	1·92–	1·36–	0·95–
1–2 fathoms	0·41+	1·41+	1·50+	1·52+	1·13+	0·38+	0·40–	1·09–	1·52–	1·64–	1·22–	0·68–	0·21–
2–3 ,, ...	0·2+	1·0 +	1·28+	1·31+	1·09+	0·46+	0·19–	0·70–	1·09–	1·09–	0·75–	0·3 –	0·0
3–4 ,, ...	—	0·3 +	0·5 +	0·7 +	0·78+	0·36+	0·10–	0·48–	0·7 –	0·5 –	0·3 –	—	—
4–5 ,, ...	—	—	—	—	0·3 +	0·2 +	0·0	0·2 –	—	—	—	—	—

STATION D—RANGE III.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·09–	0·62+	1·18+	1·81+	1·55+	0·47+	0·59–	1·58–	2·16–	2·52–	2·14–	1·38–	0·81–
1–2 fathoms	0·54+	1·30+	1·58+	1·98+	1·82+	0·89+	0·06–	1·18–	1·73–	2·13–	1·68–	0·80–	0·16–
2–3 ,, ...	0·4 +	1·0 +	1·48+	1·80+	1·78+	1·03+	0·01+	1·05–	1·24–	1·44–	1·0 –	0·4 –	0·0
3–4 ,, ...	—	—	1·0 +	1·0 +	1·44+	0·87+	0·05–	0·80–	0·7 –	0·6 –	—	—	—
4–5 ,, ...	—	—	—	—	0·6 +	0·4 +	0·0	0·2 –	—	—	—	—	—

STATION D—RANGE IV.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·0	0·91+	1·31+	1·62+	1·66+	0·97+	0.34–	1.73–	2·69–	3·01–	2·93–	1·89–	1·01–
1–2 fathoms	0·46+	1·40+	1·92+	2·21+	2·03+	1·33+	0·09–	1·51–	2·23–	2·51–	2·10–	1·08–	0·49–
2–3 ,, ...	0·3 +	0·8 +	1·95+	2·32+	2·10+	1·39+	0·0	1·26–	1·79–	1·68–	1·2 –	0·5 –	0·2 –
3–4 ,, ...	—	—	0·8 +	1·8 +	1·9 +	1·2 +	0·0	1·0 –	1·4 –	1·0 –	—	—	—
4–5 ,, ...	—	—	—	—	1·2 +	0·8 +	0·0	0·5 –	0–5 –	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow : Flood + and Ebb —

STATION E—RANGE I.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·31+	0·40+	0·59+	0·62+	0·51+	0·12+	0·56—	0·91—	1·24—	1·49—	1·22—	0·36—	0·06—
1–2 fathoms	0·74+	1·01+	1·16+	1·05+	0·92+	0·46+	0·22—	0·70—	1·12—	1·22—	0·77—	0·02—	0·30+
2–3 ,, ...	0·57+	0·96+	1·07+	0·99+	0·94+	0·54+	0·08—	0·52—	0·74—	0·65—	0·26—	0·07+	0·21+
3–4 ,, ...	0·1 +	0·3 +	0·7 +	0·6 +	0·6 +	0·4 +	0·0	0·3 —	0·4 —	0·3 —	0·1 —	0·0	0·0
4–5 ,, ...	—	—	—	—	0·3 +	0·2 +	0·0	0·1 —	—	—	—	—	—

STATION E—RANGE II.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·19+	1·00+	1·39+	1·71+	1·17+	0·33+	0·61—	1·38—	1·87—	2·21—	1·81—	1·11—	0·54—
1–2 fathoms	0·41+	1·09+	1·33+	1·49+	1·24+	0·59+	0·29—	1·12—	1·56—	1·76—	1·26—	0·59—	0·14—
2–3 ,, ...	0·3 +	0·90+	0·87+	1·09+	1·07+	0·67+	0·07—	0·88—	1·14—	1·17—	0·52—	0·2 —	0·0
3–4 ,, ...	—	0·4 +	0·4 +	0·75+	0·75+	0·47+	0·14—	0·70—	0·75—	0·6 —	0·2 —	—	—
4–5 ,, ...	—	—	—	—	0·3 +	0·2 +	0·0	0·3 —	—	—	—	—	—

STATION E—RANGE III.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·08+	1·27+	1·71+	1·78+	1·56+	0·63+	0·47—	1·54—	2·10—	2·53—	2·07—	1·31—	0·72—
1–2 fathoms	0·66+	1·45+	1·73+	1·81+	1·66+	0·91+	0·16—	1·28—	1·72—	2·18—	1·75—	0·84—	0·10—
2–3 ,, ...	0·4 +	1·07+	1·41+	1·65+	1·51+	0·90+	0·04—	1·07—	1·42—	1·65—	1·60—	0·4 —	0·0
3–4 ,, ...	—	0·4 +	0·8 +	1·0 +	1·26+	0·71+	0·04—	0·95—	1·0 —	0·8 —	1·0 —	—	—
4–5 ,, ...	—	—	—	0·2 +	0·8 +	0·4 +	0·02—	0·5 —	0·2 —	—	—	—	—

STATION E—RANGE IV.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·19—	1·22+	1·99+	2·35+	2·10+	0·79+	0·51—	1·46—	2·18—	2·73—	2·74—	1·94—	1·25—
1–2 fathoms	0·34+	1·37+	1·87+	2·07+	1·94+	0·96+	0·33—	1·32—	2·03—	2·51—	2·40—	1·26—	0·46—
2–3 ,, ...	0·2 +	1·25+	1·50+	1·69+	1·63+	1·04+	0·09—	1·09—	1·90—	2·13—	1·7 —	0·5 —	0·0
3–4 ,, ...	—	—	0·7 +	1·0 +	1·3 +	1·0 +	0·0	1·0 —	1·5 —	1·5 —	—	—	—
4–5 ,, ...	—	—	—	0·2 +	0·5 +	0·5 +	0·0	0·5 —	0·2 —	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow : Flood + and Ebb —

STATION F—RANGE I.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·11—	0·41+	0·74+	0·87+	0·67+	0·28+	0·27—	0·89—	1·28—	1·42—	1·19—	0·70—	0·41—
1–2 fathoms	0·17+	0·63+	0·85+	0·93+	0·80+	0·46+	0·12—	0·59—	0·84—	0·91—	0·70—	0·31—	0·12—
2–3 ,,	0·41+	0·67+	0·75+	0·72+	0·70+	0·44+	0·02—	0·38—	0·54—	0·52—	0·32—	0·06—	0·14+
3–4 ,,	0·47+	0·54+	0·61+	0·51+	0·37+	0·17+	0·01—	0·19—	0·34—	0·31—	0·11—	0·06+	0·30+
4–5 ,,	0·3 +	0·3 +	0·52+	0·40+	0·20+	0·03+	0·0	0·06—	0·15—	0·1 —	0·0	0·1 +	0·2 +
5–6 ,,	—	—	0·2 +	0·2 +	0·1 +	0·0	0·0	0·0	0·0	—	—	—	—

STATION F—RANGE II.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·11—	0·60+	1·01+	1·17+	0·74+	0·27+	0·67—	1·41—	1·84—	2·11—	1·79—	1·12—	0·34—
1–2 fathoms	0·42+	0·95+	1·16+	1·19+	0·97+	0·74+	0·02—	0·80—	1·34—	1·44—	1·07—	0·47—	0·01+
2–3 ,,	0·79+	0·91+	1·09+	0·95+	0·93+	0·74+	0·12+	0·47—	0·77—	0·77—	0·47—	0·07+	0·56+
3–4 ,,	0·5 +	0·6 +	0·7 +	0·74+	0·79+	0·59+	0·16+	0·32—	0·44—	0·5 —	0·3 —	0·1 +	0·5 +
4–5 ,,	0·2 +	0·3 +	0·4 +	0·4 +	0·5 +	0·4 +	0·10+	0·15—	0·2 —	0·2 —	0·0	0·2 +	0·2 +
5–6 ,,	—	—	—	0·1 +	0·2 +	0·2 +	0·0	0·0	0·0	—	—	—	—

STATION F—RANGE III.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·02+	0·91+	1·35+	1·45+	1·22+	0·46+	0·55—	1·66—	2·35—	2·78—	2·29—	1·37—	0·70—
1–2 fathoms	0·37+	1·14+	1·44+	1·61+	1·37+	0·57+	0·34—	1·38—	1·95—	2·20—	1·51—	0·69—	0·19—
2–3 ,,	0·65+	1·13+	1·31+	1·39+	1·17+	0·65+	0·08—	1·05—	1·48—	1·74—	0·92—	0·15—	0·0
3–4 ,,	0·3 +	0·7 +	0·95+	0·99+	0·89+	0·64+	0·05—	0·85—	1·09—	1·0 —	0·4 —	0·0	0·0
4–5 ,,	0·0	0·2 +	0·5 +	1·02+	0·93+	0·64+	0·01—	0·66—	0·5 —	0·4 —	0·1 —	—	—
5–6 ,,	—	—	—	0·4 +	0·4 +	0·3 +	0·0	0·3 —	0·2 —	—	—	—	—

STATION F—RANGE IV.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·07—	1·11+	1·51+	1·56+	1·21+	0·41+	0·74—	1·74—	2·17—	2·74—	2·19—	1·49—	1·01—
1–2 fathoms	0·55+	1·41+	1·61+	1·79+	1·52+	0·62+	0·51—	1·52—	1·87—	2·32—	1·61—	0·86—	0·31—
2–3 ,,	0·82+	1·26+	1·49+	1·89+	1·57+	0·67+	0·31—	1·24—	1·56—	1·87—	1·21—	0·39—	0·10+
3–4 ,,	0·3 +	0·92+	1·23+	1·69+	1·39+	0·61+	0·21—	0·97—	1·19—	1·37—	0·85—	0·2 —	0·2 +
4–5 ,,	—	0·3 +	0·6 +	1·36+	1·17+	0·52+	0·14—	0·69—	0·84—	0·85—	0·2 —	—	—
5–6 ,,	—	—	—	0·4 +	0·6 +	0·3 +	0·05—	0·3 —	0·2 —	—	—	—	—
6–7 ,,	—	—	—	—	0·3 +	0·2 +	0·0	0·1 —	—	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow: Flood + and Ebb —

STATION G—RANGE II.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·19+	0·70+	0·89+	0·60+	0·01—	0·39—	0·62—	0·89—	1·34—	1·60—	1·33—	0·80—	0·45—
1–2 fathoms	0·48+	0·84+	1·02+	0·87+	0·42+	0·06—	0·43—	0·66—	0·97—	1·06—	0·71—	0·37—	0·07—
2–3 ,, ...	0·47+	0·86+	0·92+	0·93+	0·67+	0·16+	0·26—	0·44—	0·62—	0·65—	0·38—	0·20—	0·16+
3–4 ,, ...	0·3 +	0·67+	0·67+	0·85+	0·77+	0·30+	0·09—	0·31—	0·31—	0·42—	0·2 —	0·1 —	0·2 +
4–5 ,, ...	—	0·2 +	0·3 +	0·72+	0·70+	0·34+	0·01+	0·27—	0·34—	0·2 —	0·1 —	—	—
5–6 ,, ...	—	—	—	—	0·2 +	0·2 +	0·0	0·2 —	—	—	—	—	—

STATION G—RANGE III.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·08—	0·42+	0·74+	0·97+	0·54+	0·38—	0·96—	1·23—	1·47—	1·75—	1·68—	1·08—	0·41—
1–2 fathoms	0·26+	0·83+	1·09+	1·27+	0·76+	0·09+	0·46—	0·80—	0·86—	1·11—	1·09—	0·64—	0·09—
2–3 ,, ...	0·62+	1·08+	1·22+	1·36+	0·99+	0·57+	0·01+	0·51—	0·60—	0·81—	0·67—	0·34—	0·15+
3·4 ,, ...	0·3 +	0·7 +	0·96+	1·15+	1·10+	0·74+	0·12+	0·31—	0·44—	0·72—	0·4 —	0·1 —	0·2 +
4–5 ,, ...	—	—	0·5 +	0·6 +	1·06+	0·71+	0·12+	0·21—	0·15—	0·3 —	0·2 —	—	—
5–6 ,, ...	—	—	—	—	0·5 +	0·3 +	0·0	0·1 —	—	—	—	—	—

STATION G—RANGE IV.

	Before High Water						After High Water						
Hourly Period:	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·02+	1·07+	1·61+	1·64+	1·23+	0·35+	0·90—	1·65—	1·98—	2·27—	2·00—	1·32—	0·70—
1–2 fathoms	0·64+	1·44+	1·74+	1·75+	1·30+	0·41+	0·62—	1·10—	1·26—	1·53—	1·24—	0·73—	0·20—
2–3 ,, ...	0·92+	1·56+	1·54+	1·64+	1·35+	0·66+	0·32—	0·73—	0·90—	1·22—	0·85—	0·38—	0·14+
3–4 ,, ...	0·4 +	0·6 +	1·0 +	1·41+	1·37+	0·83+	0·12—	0·47—	0·56—	0·8 —	0·4 —	0·1 —	0·2 +
4–5 ,, ...	—	—	0·2 +	0·7 +	1·29+	0·78+	0·07—	0·39—	0·3 —	0·3 —	—	—	—
5–6 ,, ...	—	—	—	0·3 +	0·5 +	0·4 +	0·0	0·2 —	0·2 —	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow: Flood + and Ebb —

STATION H.—RANGE I.

Hourly Period:	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·10+	0·45+	0·66+	0·89+	0·64+	0·14+	0·41—	0·66—	1·18—	1·31—	1·14—	0·71—	0·30—
1–2 fathoms	0·12+	0·38+	0·61+	0·79+	0·70+	0·33+	0·08—	0·38—	0·61—	0·72—	0·54—	0·19—	0·02—
2–3 ,, ...	0·1 +	0·23+	0·52+	0·68+	0·66+	0·32+	0·04—	0·27—	0·40—	0·35—	0·2 —	0·1 —	0·0
3–4 ,, ...	0·0	0·1 +	0·3 +	0·3 +	0·31+	0·12+	0·02—	0·12—	0·2 —	0·2 —	0·1 —	0·0	0·0
4–5 ,, ...	—	0·0	0·1 +	0·1 +	0·15+	0·1 +	0·0	0·0	0·1 —	0·1 —	0·0	—	—

STATION H.—RANGE II.

Hourly Period:	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·14+	0·88+	1·34+	1·31+	0·89+	0·20+	0·51—	1·13—	1·70—	1·83—	1·50—	0·94—	0·41—
1–2 fathoms	0·49+	1·06+	1·43+	1·42+	1·04+	0·42+	0·23—	0·86—	1·43—	1·56—	1·21—	0·47—	0·06—
2–3 ,, ...	0·68+	1·03+	1·31+	1·35+	1·04+	0·54+	0·06—	0·71—	1·19—	1·29—	0·88—	0·03—	0·07+
3–4 ,, ...	0·3 +	0·7 +	1·18+	1·20+	0·91+	0·52+	0·07+	0·43—	0·84—	0·86—	0·4 —	0·0	0·1 +
4–5 ,, ...	—	—	0·2 +	0·6 +	0·6 +	0·4 +	0·03+	0·2 —	0·4 —	0·2 —	—	—	—

STATION H.—RANGE III.

Hourly Period:	Before High Water						After High Water.						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·31+	1·02+	1·28+	1·41+	1·19+	0·61+	0·20—	1·11—	1·80—	2·00—	1·88—	1·29—	0·60—
1–2 fathoms	0·87+	1·37+	1·56+	1·62+	1·28+	0·71+	0·02—	0·38—	0·98—	1·59—	1·42—	0·65—	0·01+
2–3 ,, ...	0·86+	1·13+	1·36+	1·54+	1·31+	0·77+	0·14+	0·16—	0·68—	1·37—	1·03—	0·27—	0·30+
3–4 ,, ...	0·4 +	0·7 +	0·9 +	1·39+	1·26+	0·70+	0·26+	0·09—	0·51—	0·93—	0·7 —	0·1 —	0·2 +
4–5 ,, ...	—	—	0·1 +	0·6 +	1·02+	0·48+	0·14+	0·02—	0·3 —	0·4 —	—	—	—
5–6 ,, ...	—	—	—	—	—	0·2 +	0·0	0·0	—	—	—	—	—

STATION H.—RANGE IV.

Hourly Period:	Before High Water						After High Water.						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·25+	1·43+	2·03+	2·23+	1·89+	1·14+	0·34—	1·29—	2·33—	2·96—	2·61—	1·77—	0·91—
1–2 fathoms	0·76+	1·56+	1·96+	2·27+	1·99+	1·26+	0·32+	0·61—	1·76—	2·57—	2·00—	1·07—	0·42—
2–3 ,, ...	0·80+	1·31+	1·80+	2·23+	1·94+	1·19+	0·41+	0·36—	1·44—	2·21—	1·32—	0·60—	0·2 —
3–4 ,, ...	0·2 +	0·6 +	1·54+	2·01+	1·85+	1·20+	0·38+	0·29—	1·15—	1·63—	0·4 —	0·1 —	—
4–5 ,, ...	—	—	—	0·7 +	1·60+	1·03+	0·24+	0·24—	0·7 —	0·5 —	—	—	—
5–6 ,, ...	—	—	—	—	0·2 +	0·5 +	0·0	0·1 —	—	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow : Flood + and Ebb —

STATION I—RANGE I.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	—	—	—	—	—	—	0·39–	0·96–	1·51–	1·62–	1·23–	0·68–	0·38–
1–2 fathoms	—	—	—	—	—	—	0·24–	0·76–	1·32–	1·34–	0·83–	0·30–	0·04+
2–3 ,, ...	—	—	—	—	—	—	0·20–	0·66–	1·18–	1·21–	0·63–	0·17–	0·14+
3–4 ,, ...	—	—	—	—	—	—	0·18–	0·56–	1·03–	1·06–	0·51–	0·01–	0·24+
4–5 ,, ...	—	—	—	—	—	—	0·12–	0·42–	0·79–	0·84–	0·4 –	0·0	0·3 +
5–6 ,, ...	—	—	—	—	—	—	0·1 –	0·3 –	0·5 –	0·7 –	0·3 –	0·0	0·1 +
6–7 ,, ...	—	—	—	—	—	—	0·1 –	0·2 –	0·2 –	0·0	—	—	—

STATION I—RANGE II.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·16+	1·09+	2·39+	2·10+	1·34+	0·81+	—	—	—	—	—	—	—
1–2 fathoms	0·40+	1·29+	2·33+	2·17+	1·36+	0·82+	—	—	—	—	—	—	—
2–3 ,, ...	0·47+	1·34+	2·15+	2·27+	1·42+	0·81+	—	—	—	—	—	—	—
3–4 ,, ...	0·43+	1·17+	1·96+	2·29+	1·41+	0·66+	—	—	—	—	—	—	—
4–5 ,, ...	0·37+	0·80+	1·85+	2·10+	1·26+	0·51+	—	—	—	—	—	—	—
5–6 ,, ...	0·2 +	0·4 +	1·0 +	1·4 +	0·8 +	0·4 +	—	—	—	—	—	—	—
6–7 ,, ...	—	—	—	0·5 +	0·5 +	0·3 +	—	—	—	—	—	—	—

STATION I—RANGE III.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·13+	0·96+	2·14+	2·86+	2·26+	0·85+	0·26–	1·28–	2·44–	3·02–	2·13–	1·02–	0·42–
1–2 fathoms	0·39+	1·26+	2·24+	2·86+	2·17+	0·91+	0·17–	1·18–	2·29–	2·73–	1·66–	0·55–	0·06–
2–3 ,, ...	0·57+	1·30+	2·22+	2·79+	2·09+	0·96+	0·13–	1·12–	2·20–	2·54–	1·41–	0·32–	0·03+
3–4 ,, ...	0·59+	1·10+	2·04+	2·62+	1·94+	0·96+	0·07–	1·06–	2·13–	2·35–	1·19–	0·16–	0·09+
4–5 ,, ...	0·5 +	0·71+	1·73+	2·42+	1·76+	0·96+	0·02+	0·96–	2·01–	2·06–	0·86–	0·1 –	0·15+
5–6 ,, ...	0·2 +	0·4 +	1·0 +	2·1 +	1·60+	0·75+	0·06+	0·85–	1·6 –	1·5 –	0·4 –	0·0	0·1 +
6–7 ,, ...	—	—	0·1 +	0·7 +	1·0 +	0·5 +	0·1 +	0·5 –	1·0 –	0·3 –	—	—	—
7–8 ,, ...	—	—	—	—	—	0·1 +	0·1 +	—	—	—	—	—	—

STATION I—RANGE IV.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·36+	1·37+	3·07+	3·73+	2·78+	1·09+	0·77–	2·10–	3·08–	3·45–	2·53–	1·59–	0·37–
1–2 fathoms	0·65+	1·65+	3·13+	3·78+	2·66+	1·05+	0·66–	1·85–	2·69–	2·94–	1·91–	0·95–	0·13–
2–3 ,, ...	0·76+	1·50+	3·06+	3·84+	2·59+	1·02+	0·62–	1·78–	2·58–	2·58–	1·28–	0·46–	0·03+
3–4 ,, ...	0·71+	1·26+	2·98+	4·01+	2·61+	1·01+	0·58–	1·69–	2·44–	2·27–	0·93–	0·16–	0·11+
4–5 ,, ...	0·3 +	0·7 +	2·88+	4·09+	2·69+	1·02+	0·53–	1·61–	2·23–	1·76–	0·48–	0·01+	0·14+
5–6 ,, ...	—	0·1 +	2·0 +	3·5 +	2·0 +	0·9 +	0·4 –	1·1 –	1·7 –	1·0 –	0·1 –	—	—
6–7 ,, ...	—	—	—	0·5 +	1·0 +	0·5 +	0·3 –	0·5 –	0·4 –	—	—	—	—
7–8 ,, ...	—	—	—	—	—	0·2 +	0·1 –	—	—	—	—	—	—

TABLE 3—*Average Speeds in Feet per Second of Current in Centre of River in Layers of One Fathom Thickness and during Periods of One Hour—continued.*

Direction of Flow : Flood + and Ebb —

STATION K—RANGE I.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·20–	0·39+	1·51+	1·37+	1·11+	0·51+	0·54–	1·52–	2·12–	2·01–	1·26–	0·66–	0·44–
1–2 fathoms	0·06+	0·62+	1·56+	1·41+	0·97+	0·61+	0·29–	1·43–	2·02–	1·76–	0·97–	0·37–	0·17–
2–3 ,, ...	0·22+	0·91+	1·69+	1·40+	0·99+	0·56+	0·32–	1·37–	1·84–	1·57–	0·79–	0·14–	0·07+
3–4 ,, ...	0·40+	1·02+	1·77+	1·52+	1·12+	0·58+	0·25–	1·42–	1·74–	1·46–	0·72–	0·09–	0·16+
4–5 ,, ...	0·55+	1·15+	1·81+	1·67+	1·23+	0·72+	0·07–	1·27–	1·66–	1·31–	0·63–	0·05–	0·22+
5–6 ,, ...	0·66+	1·29+	1·84+	1·66+	1·22+	0·77+	0·02–	1·16–	1·57–	1·15–	0·47–	0·04+	0·34+
6–7 ,, ...	0·7 +	1·3 +	1·9 +	1·6 +	1·1 +	0·7 +	0·0	1·0 –	1·5 –	1·0 –	0·4 –	0·1 +	0·4 +
7–8 ,, ...	0·6 +	1·3 +	1·9 +	1·5 +	1·0 +	0·6 +	0·1 +	0·9 –	1·4 –	0·8 –	0·3 –	0·1 +	0·4 +
8–9 ,, ...	0·3 +	0·7 +	1·2 +	1·0 +	0·7 +	0·5 +	0·1 +	0·8 –	1·1 –	0·6–	0·2 –	0·1 +	0·2 +
9–10 ,, ...	—	—	—	—	0·4 +	0·3 +	0·1 +	0·5 –	—	—	—	—	—

STATION K—RANGE IV.

Hourly Period :	Before High Water						After High Water						
	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·08+	1·88+	3·89+	4·92+	3·80+	1·40+	1·28–	3·36–	4·49–	4·18–	2·51–	1·69–	1·12–
1–2 fathoms	0·06+	1·78+	3·89+	4·98+	3·85+	1·38+	1·31–	3·30–	4·25–	3·88–	2·28–	1·41–	0·92–
2–3 ,, ...	0·41+	2·04+	3·91+	4·95+	3·98+	1·45+	1·21–	3·16–	4·08–	3·66–	2·19–	1·09–	0·52–
3–4 ,, ...	0·81+	2·21+	3·80+	4·85+	3·92+	1·46+	1·09–	2·99–	3·89–	3·40–	1·98–	0·71–	0·15–
4–5 ,, ...	0·74+	2·10+	3·65+	4·62+	3·89+	1·50+	1·12–	2·98–	3·72–	3·18–	1·72–	0·55–	0·08–
5–6 ,, ...	0·60+	2·00+	3·49+	4·24+	3·66+	1·44+	1·05–	2·85–	3·62–	3·14–	1·86–	0·70–	0·15–
6–7 ,, ...	0·54+	1·88+	3·21+	3·80+	3·38+	1·46+	1·10–	2·88–	3·48–	3·00–	1·88–	0·66–	0·12–
7–8 ,, ...	0·5 +	1·7 +	3·0 +	3·4 +	3·20+	1·48+	1·10–	2·79–	3·2 –	2·8 –	1·8 –	0·6 –	0·1 –
8–9 ,, ...	—	—	2·0 +	2·3 +	2·3 +	1·4 +	1·0 –	2·7 –	2·7 –	2·0 –	—	—	—
9–10 ,, ...	—	—	—	—	1·5 +	1·2 +	0·8 –	2·0 –	—	—	—	—	—

TABLE 4—*Example of Method of Computing Volumes of Water passing a Station during a Flood of 6 hours and an Ebb of 6½ hours*

STATION E—RANGE II.

Average Speeds in Feet per Second (from Table 3).

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	0·19+	1·00+	1·39+	1·71+	0·17+	0·33+	0·61–	1·38–	1·87–	2·21–	1·81–	1·11–	0·54–
1–2 fathoms	0·41+	1·09+	1·33+	1·49+	1·24+	0·59+	0·29–	1·12–	1·56–	1·76–	1·26–	0·59–	0·14–
2–3 ,,	0·3 +	0·90+	0·87+	1·09+	1·07+	0·67+	0·07–	0·88–	1·14–	1·17–	0·52–	0·2 –	0·0
3–4 ,,	—	0·4 +	0·4 +	0·75+	0·75+	0·47+	0·14–	0·70–	0·75–	0·6 –	0·2 –	—	—
4–5 ,,	—	—	—	—	0·3 +	0·2 +	0·0	0·3 –	—	—	—	—	—

Average Height of Tide during Periods of Observation.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Height (feet)	4·0	5·2	7·3	9·8	12·0	13·1	13·9	12·7	10·6	7·8	5·4	3·7	3·0

Cross-sectional Areas in Square Feet for each Hourly Period from Cross-section Diagram, Plate *37*.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	2,415	2,440	2,470	2,530	2,635	2,785	2.990	2,740	2,550	2,480	2,435	2,405	2,390
1–2 fathoms	2,295	2,325	2,360	2,405	2,445	2,460	2,485	2,450	2,425	2,370	2,335	2,285	2,260
2–3 ,,	1,575	1,845	2,145	2,285	2,340	2,360	2,375	2,350	2,310	2,185	1,895	1,510	1,280
3–4 ,,	—	255	715	1,510	1,985	2,130	2,210	2,090	1,685	865	295	—	—
4–5 ,,	—	—	—	—	395	635	940	575	—	—	—	—	—

Volumes of Water in Cubic Feet per second.

	Before High Water						After High Water						
Hourly Period :	6–5	5–4	4–3	3–2	2–1	1–0	0–1	1–2	2–3	3–4	4–5	5–6	6–6·5
Surface–1 fathom	460+	2,240+	3,430+	4,320+	3,080+	920+	1,820–	3,780–	4,770–	5,490–	4,400–	2,660–	1,290–
1–2 fathoms	940+	2,530+	3,135+	3,580+	3,030+	1,450+	720–	2,740–	3,780–	4,160–	2,935–	1,345–	315–
2–3 ,,	475+	1,655+	1,865+	2,485+	2,500+	1,580+	165–	2,070–	2,630–	2,550–	985–	300–	0
3–4 ,,	—	100+	285+	1,135+	1,485+	1,000+	310–	1,465–	1,260–	520–	60–	—	—
4–5 ,,	—	—	—	—	120+	125+	0	170–	—	—	—	—	—
Totals	1,875+	6,725+	8,715+	11,520+	10,215+	5,075+	3,015–	10,225–	12,440–	12,720–	8,380–	4,305–	800–
	44,125+						51,885–						

Multiplying by 3,600 :—

Total volume of Flood .. .. 159 million cubic feet.

,, Ebb .. .. 187 ,,

Applying the factor 0·8 for side currents :—

Corrected total volume of Flood .. .. .. 127 million cubic feet.

,, ,, Ebb .. .. .. 150 ,,

TABLE 5—*Volumes of Water in Millions of Cubic Feet passing Stations A to K during a Flood of 6 hours and an Ebb of 6½ hours*

Calculated as shown in the example, Table 4, but not corrected to Standard Ranges of Tide

Range of Tide :	I		II		III		IV	
Station	Flood	Ebb	Flood	Ebb	Flood	Ebb	Flood	Ebb
A	—	—	56	60	—	—	—	—
B	48	58	—	—	82	79	105	97
C	59	75	69	93	99	108	138	142
D	70	78	93	123	129	134	159	170
E	99	87	127	150	171	182	191	226
F	110	107	152	152	194	245	231	273
G	—	—	163	205	226	242	354	322
H	118	128	260	251	314	229	450	346
I	—	328	594	—	730	609	953	746
K	562	517	—	—	—	—	1472	1400

TABLE 6—*Volumes of Water in Millions of Cubic Feet passing Stations A to H during a Flood of 6 hours and an Ebb of 6½ hours at Standard Ranges of 6, 9·5, 13 and 16·5 feet.*

From Diagrams 1 and 2. Before final adjustment (see p. 8).

Range of Tide :	I (6·0 feet)		II (9·5 feet)		III (13·0 feet)		IV (16·5 feet)	
Station	Flood	Ebb	Flood	Ebb	Flood	Ebb	Flood	Ebb
A	—	—	53	58	—	—	—	—
B	35	48	60	66	83	83	102	95
C	48	57	67	90	105	120	142	147
D	67	67	90	107	126	139	164	175
E	85	80	128	128	176	192	200	237
F	95	97	164	156	200	238	227	278
G	—	—	166	203	255	264	362	340
H	143	140	270	268	355	—	465	—

TABLE 7—*Volumes of Water in Millions of Cubic Feet passing Stations A to G during a Flood of 6 hours and an Ebb of 6½ hours at Standard Ranges of Tide*

Final figures from Diagrams 3 and 4 (see pp. 8 and 9).

Range of Tide :	I (6·0 feet)		II (9·5 feet)		III (13·0 feet)		IV (16·5 feet)	
Station	Flood	Ebb	Flood	Ebb	Flood	Ebb	Flood	Ebb
A	33	44	50	62	71	82	99	110
B	38	48	57	68	80	90	110	120
C	47	58	71	83	100	112	132	144
D	62	70	92	105	127	140	160	176
E	79	86	123	134	166	180	207	225
F	90	100	144	157	199	214	248	272
G	116	125	185	198	256	272	338	348

TABLE 8—*Volumes of Water in Millions of Cubic Feet passing Stations H, I and K during a Flood of 6 hours and an Ebb of 6½ hours at Standard Ranges of Tide* (see pp. 8 and 9).

Range of Tide :	I (6·0 feet)		II (9·5 feet)		III (13·0 feet)		IV (16·0 feet)	
Station	Flood	Ebb	Flood	Ebb	Flood	Ebb	Flood	Ebb
H	147	158	257	268	355	300	477	350
I	—	290	560	—	750	620	980	760
K	500	450	—	—	—	—	1310	1260

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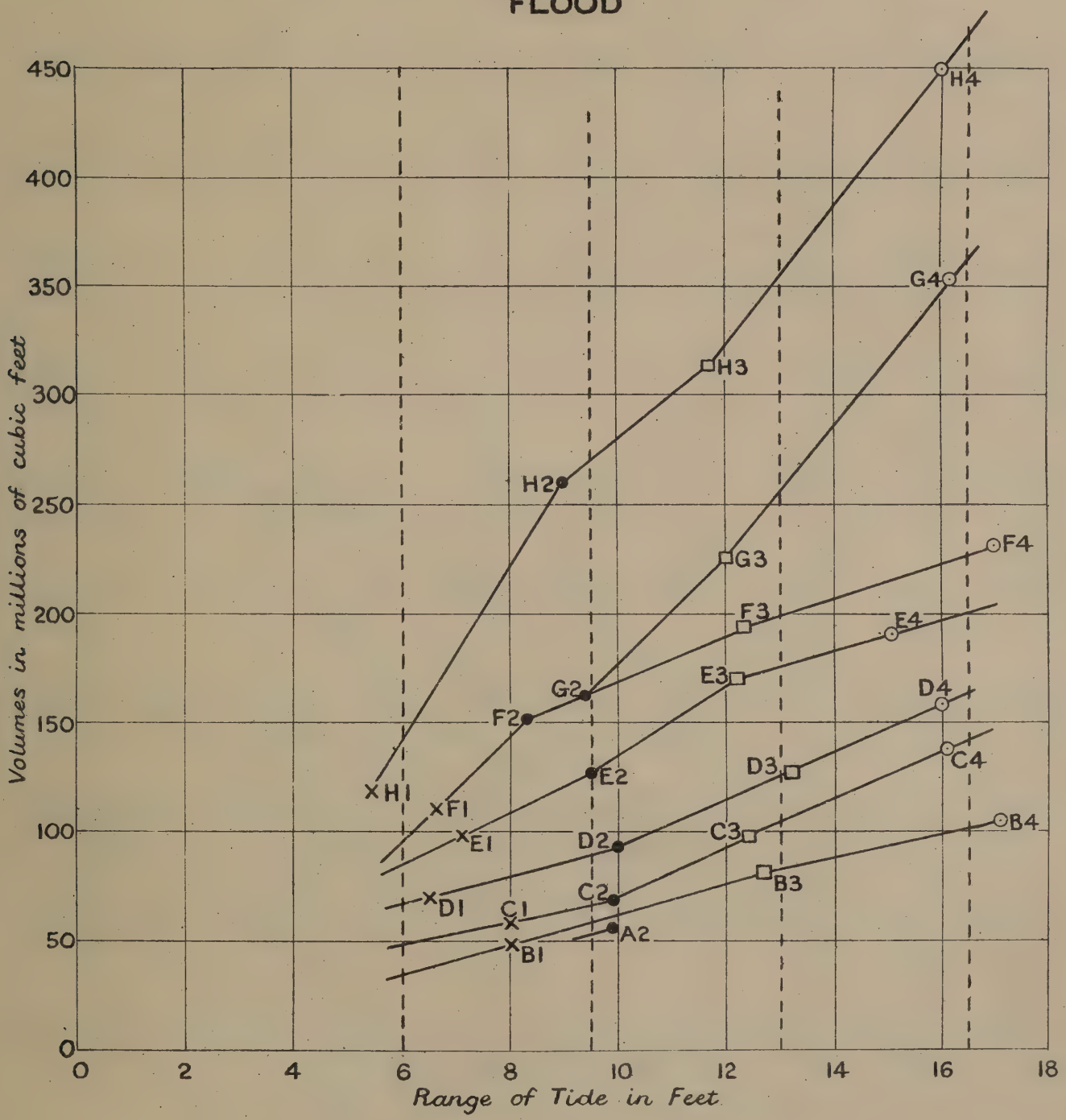
GRAPH FROM FIGURES IN TABLE 5

DIAGRAM 1



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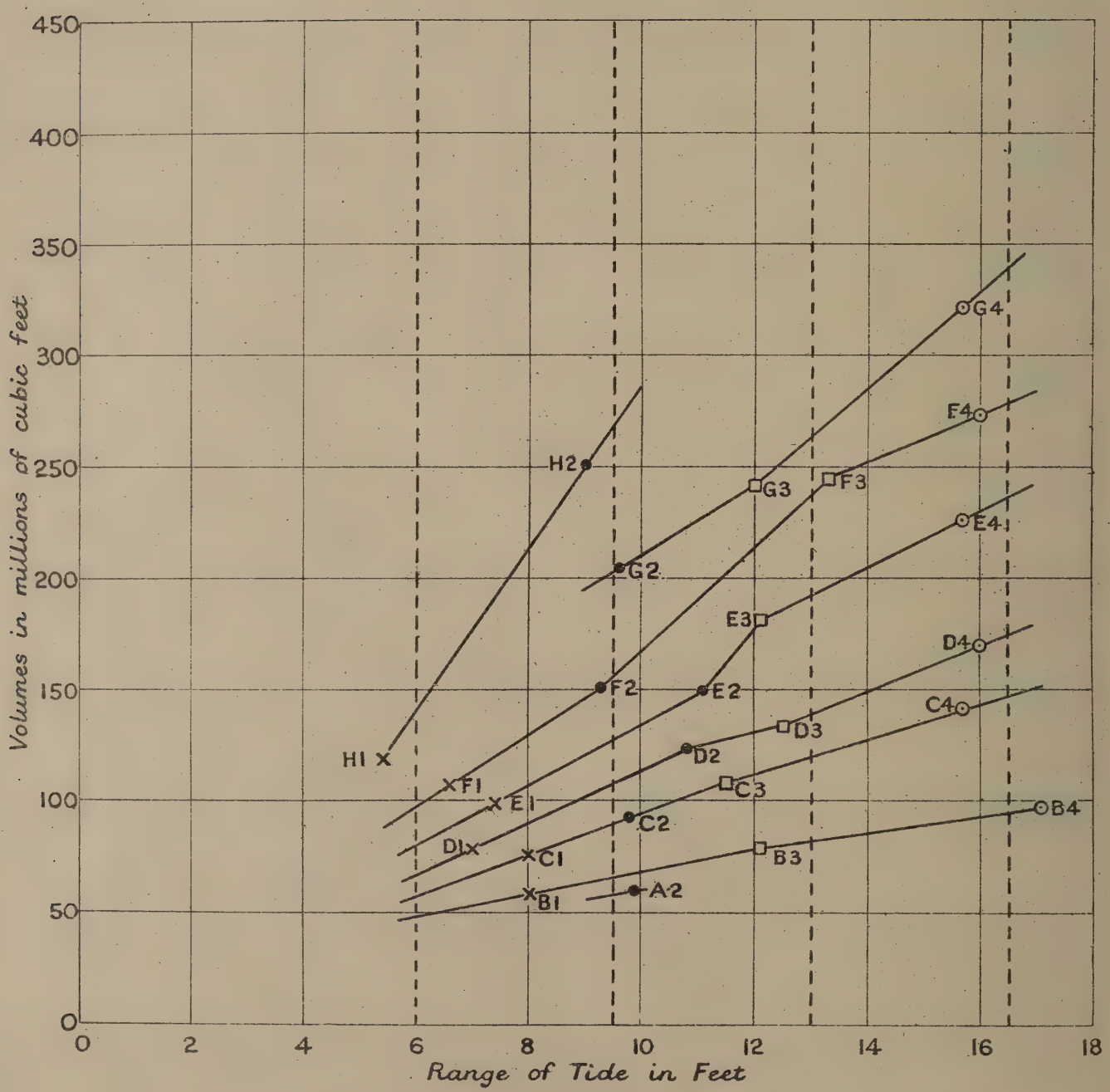
GRAPH FROM FIGURES IN TABLE 5

DIAGRAM 2



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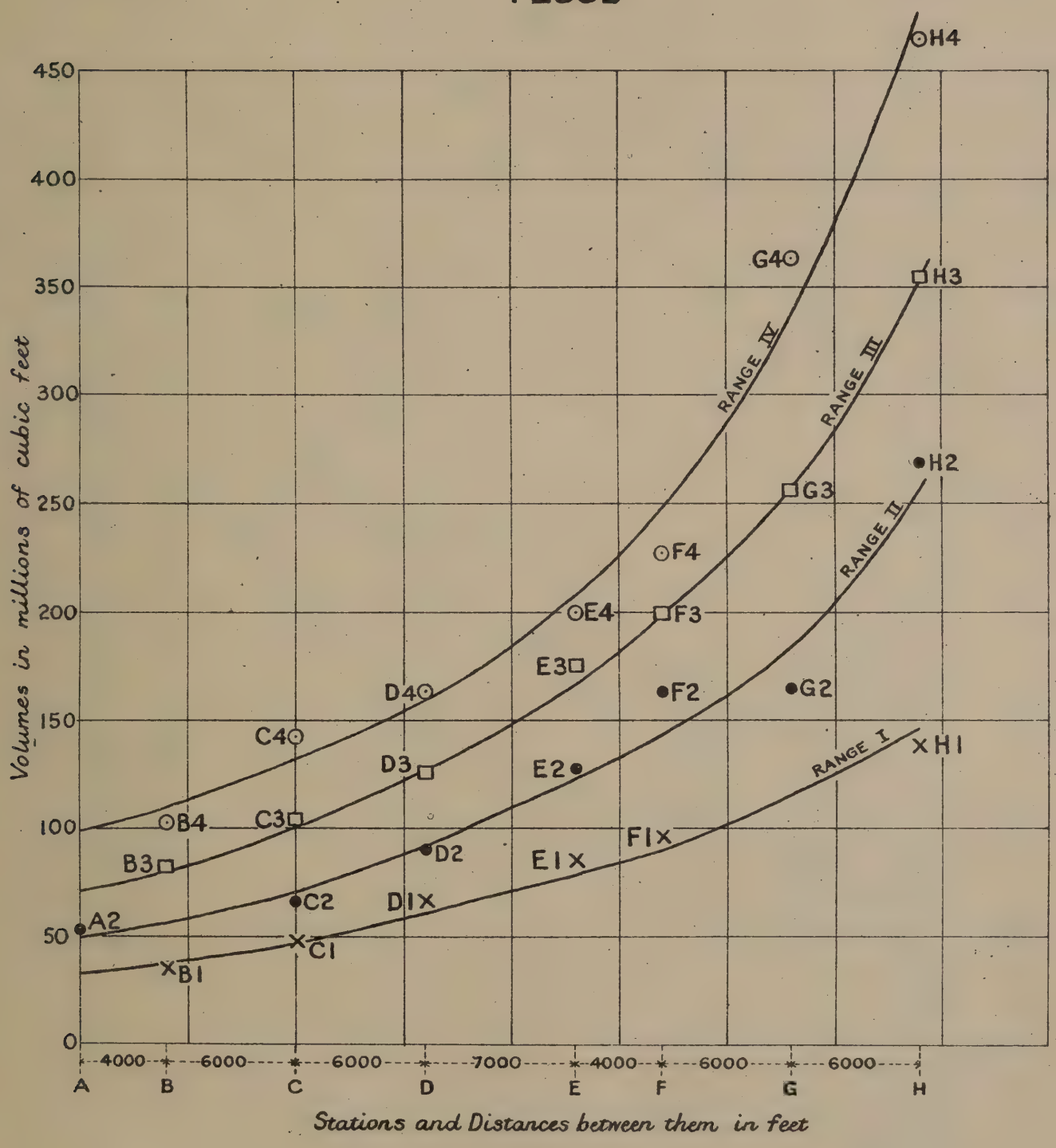
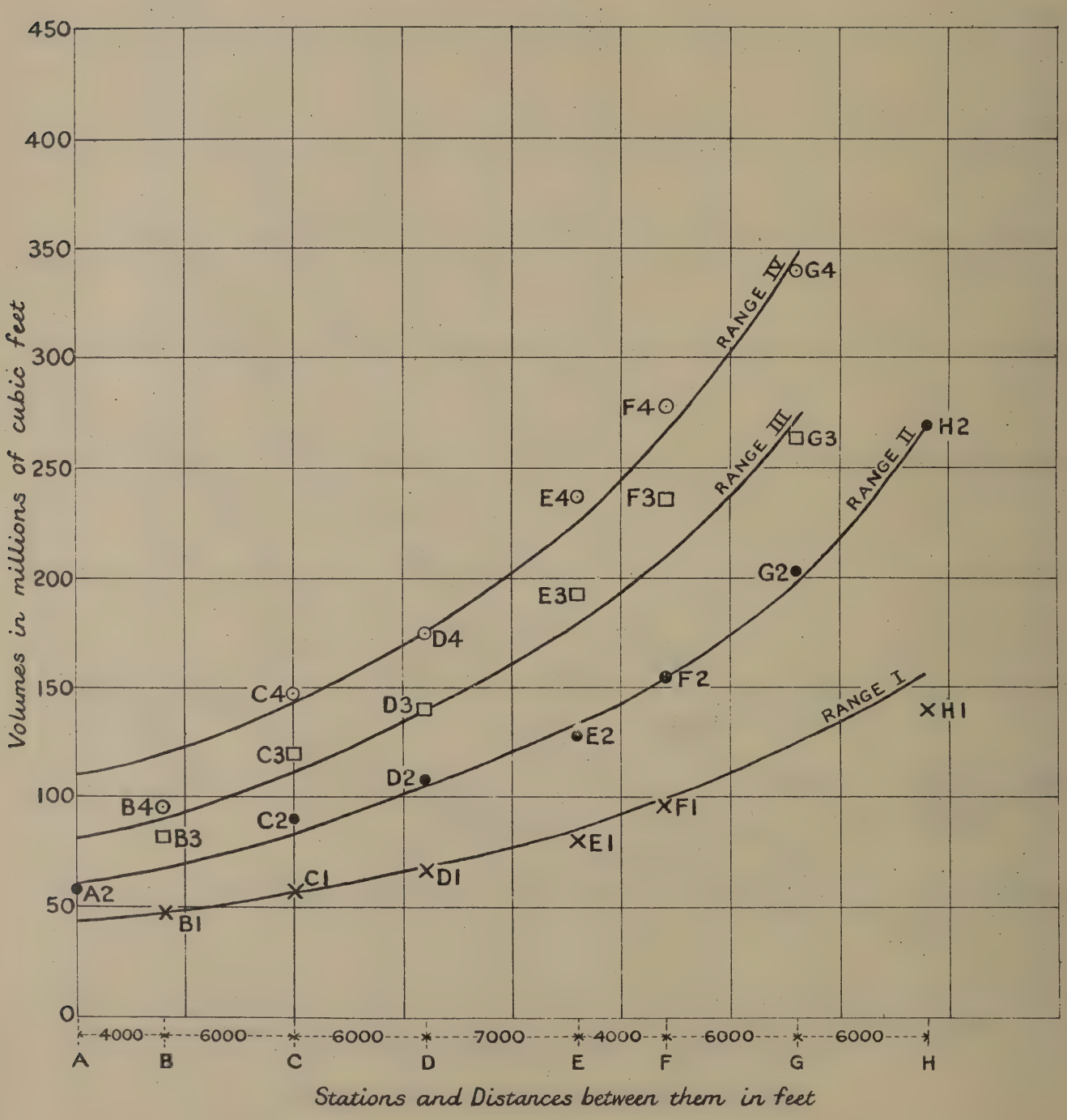
GRAPH FROM FIGURES IN TABLE 6

DIAGRAM 3



GRAPH FROM FIGURES IN TABLE 6

DIAGRAM 4



RIVER TEES SURVEY 1929

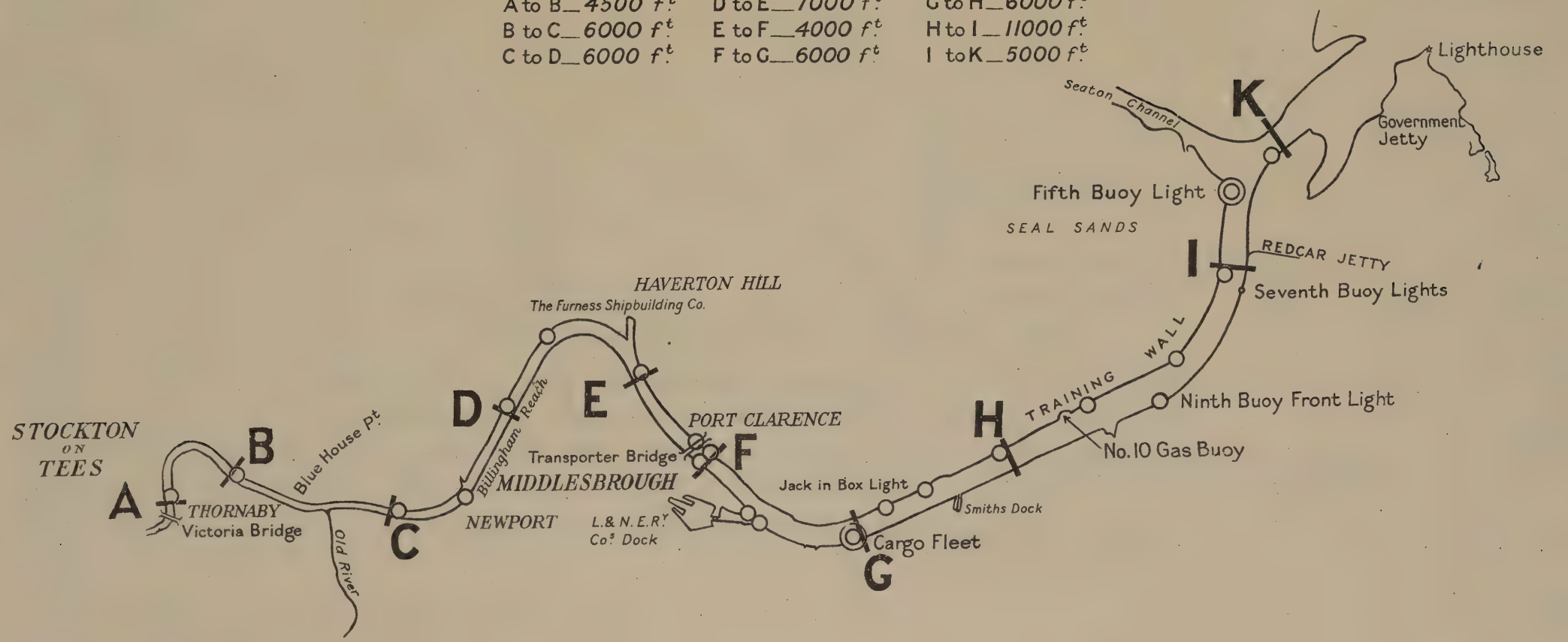
DIAGRAM SHOWING OBSERVING STATIONS

T.C.C. Automatic Tide Gauges marked thus ◎

T.C.C. Tide Gauges marked thus ○

Distances between stations

A to B 4500 ft.	D to E 7000 ft.	G to H 6000 ft.
B to C 6000 ft.	E to F 4000 ft.	H to I 11000 ft.
C to D 6000 ft.	F to G 6000 ft.	I to K 5000 ft.



CROSS SECTION OF RIVER TEES 10th April 1929.

Cross section made about 40 yds. above CROFT BRIDGE, on a line between N.E. corner of cemetery on Yorks side and white door on 1st house to North of "COMET INN" on Durham side

River shown here at 'SUMMER LEVEL', or 1'.0" on tide gauge.

Zero on height scale shows water at 'Summer Level', or 1'.0" on tide gauge.

SCALE of HEIGHT six times SCALE of WIDTH.

Height on gauge	Area of Cross Section
1'.0"	145 square feet
2'.0"	233 " "
3'.0"	386 " "
4'.0"	559 " "
5'.0"	755 " "

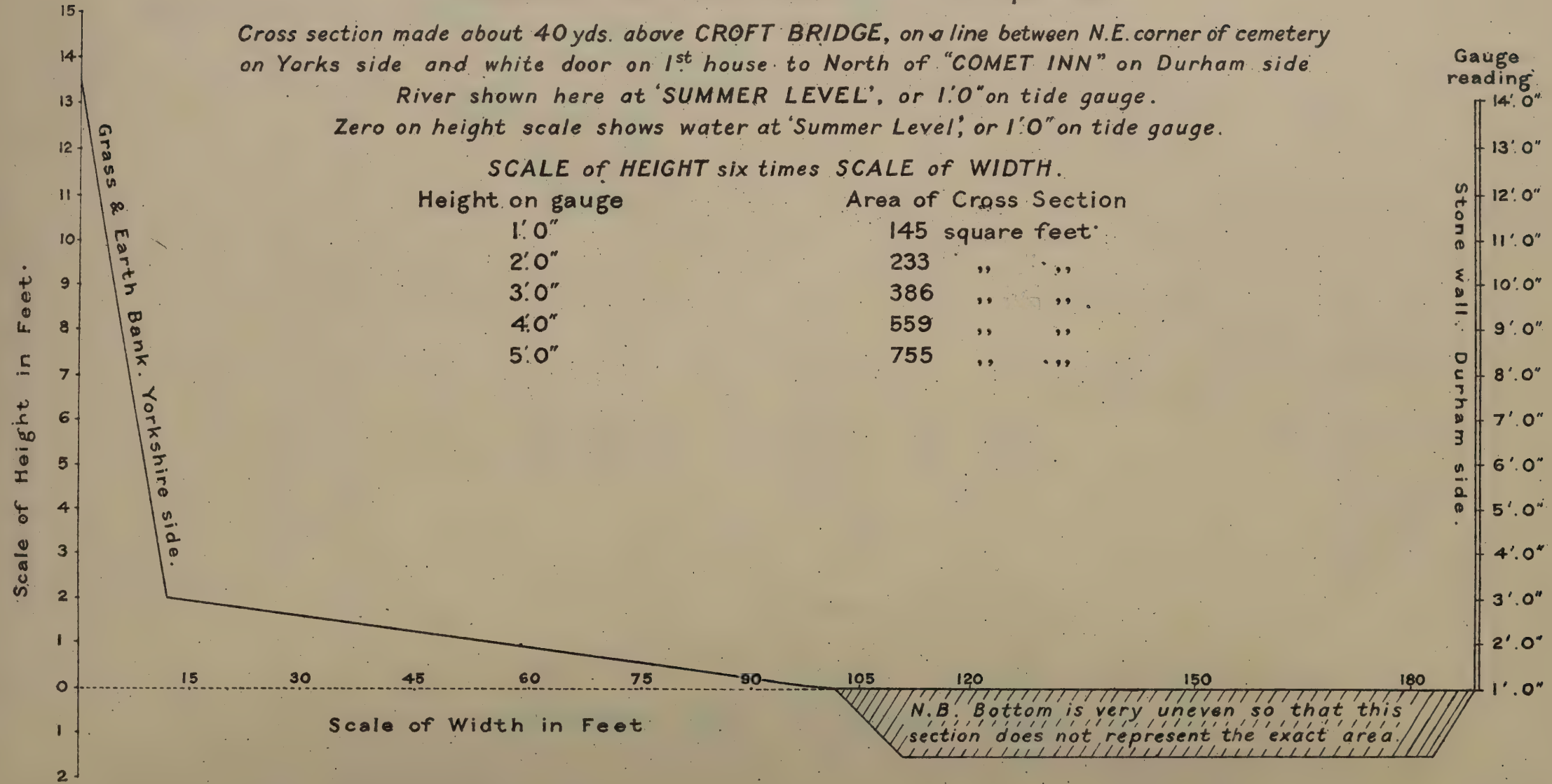


PLATE 3

RIVER TEES SURVEY 1929

Graph showing estimated Volumes of fresh water entering the Tidal Estuary compared with height of water on water level gauge at Croft Bridge.

Zero on gauge, 84'·5 above Ordnance Datum.

Estimated normal Summer Level, 1'.0" on gauge.

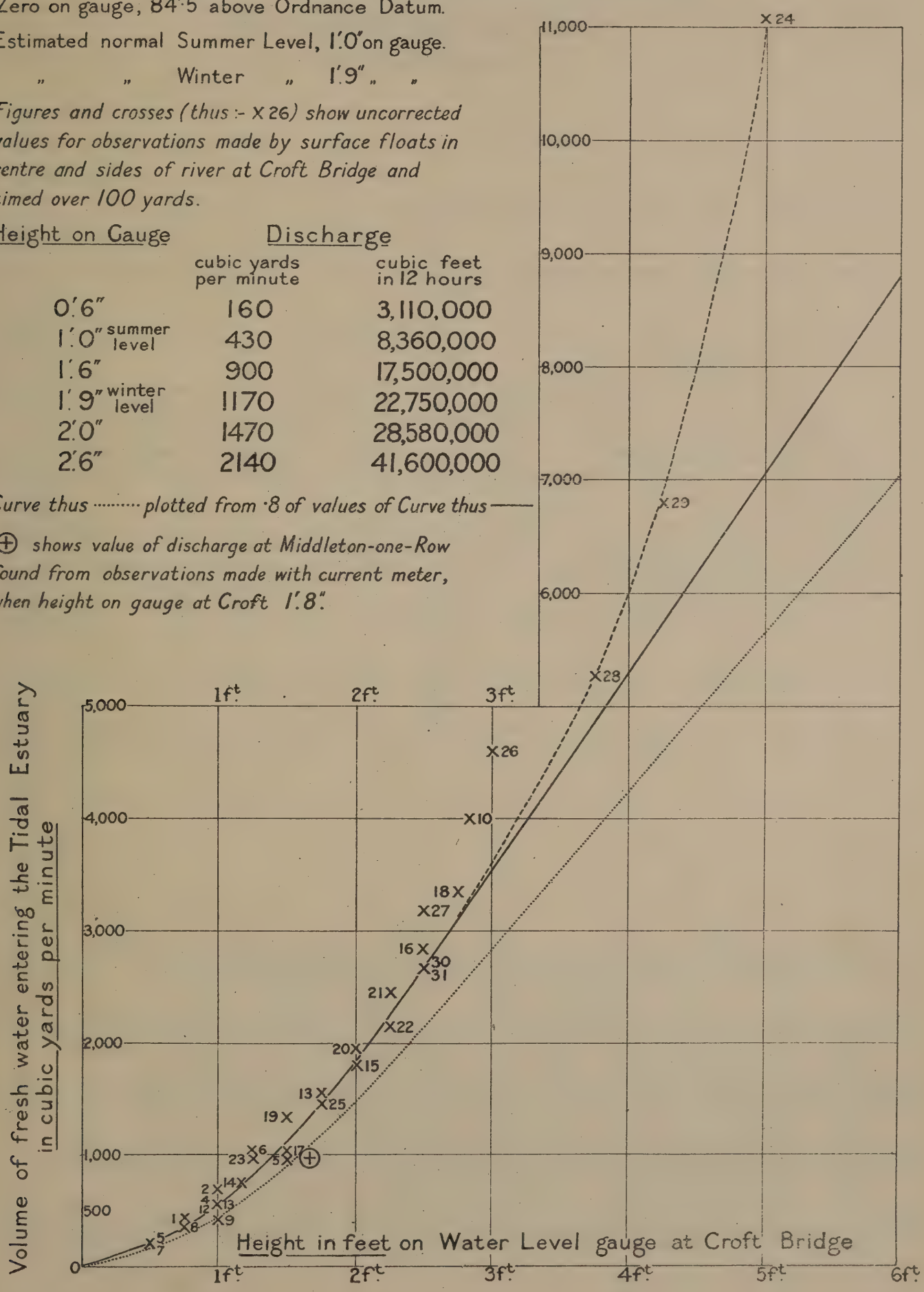
" " Winter " 1'.9" " "

Figures and crosses (thus :- X 26) show uncorrected values for observations made by surface floats in centre and sides of river at Croft Bridge and timed over 100 yards.

Height on Gauge	Discharge	
	cubic yards per minute	cubic feet in 12 hours
0'.6"	160	3,110,000
1'.0" summer level	430	8,360,000
1'.6"	900	17,500,000
1'.9" winter level	1170	22,750,000
2'.0"	1470	28,580,000
2'.6"	2140	41,600,000

Curve thus ····· plotted from ·8 of values of Curve thus ——

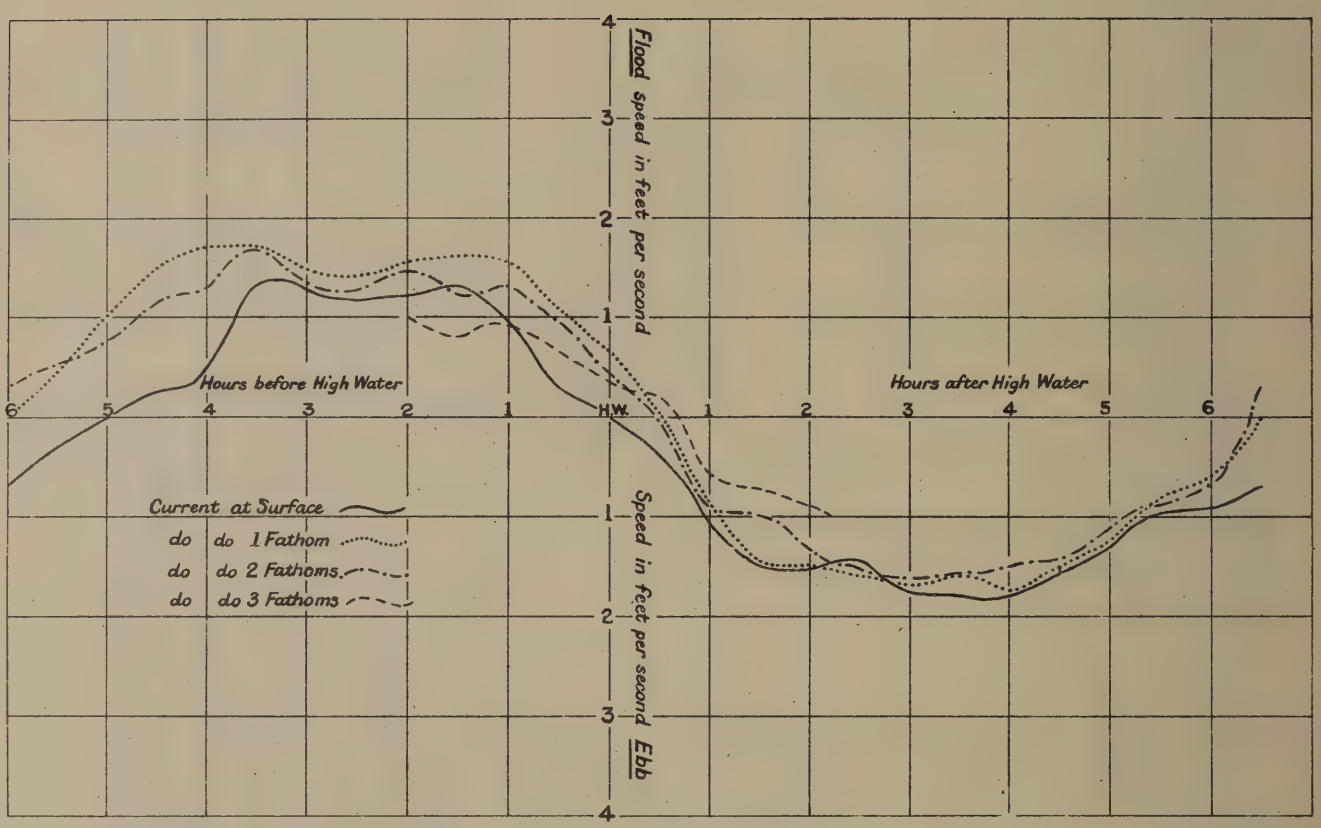
⊕ *shows value of discharge at Middleton-one-Row found from observations made with current meter, when height on gauge at Croft 1'.8".*

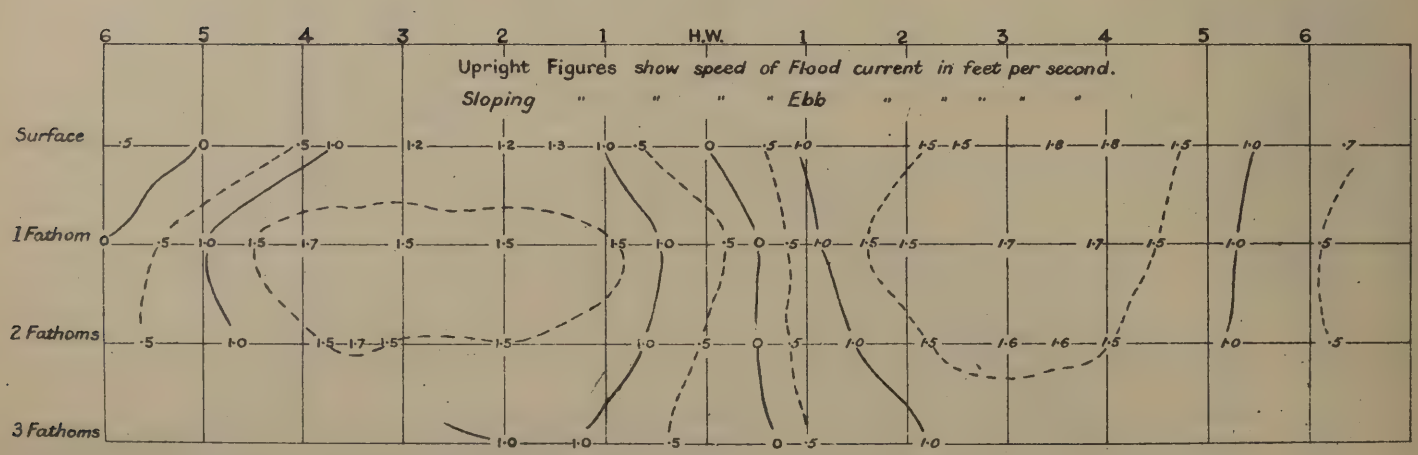


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT A.II.

Range - 8 to 11 feet

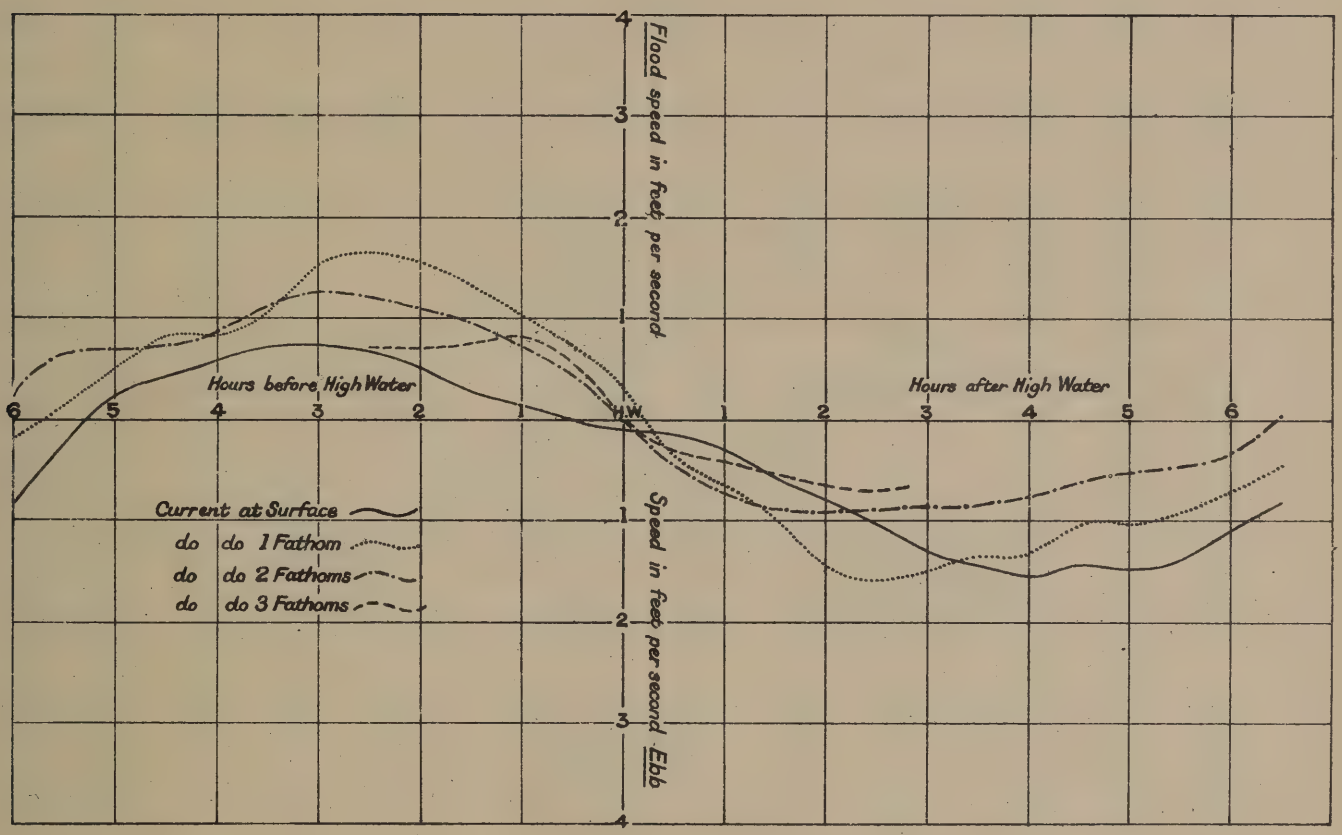


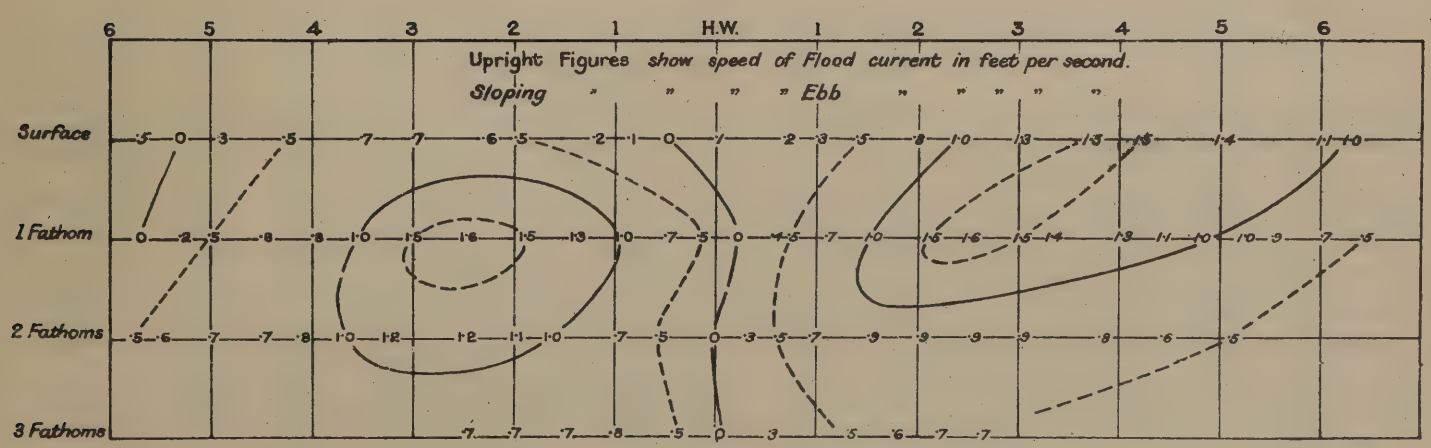


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT B.I.

Range - Below 8 feet

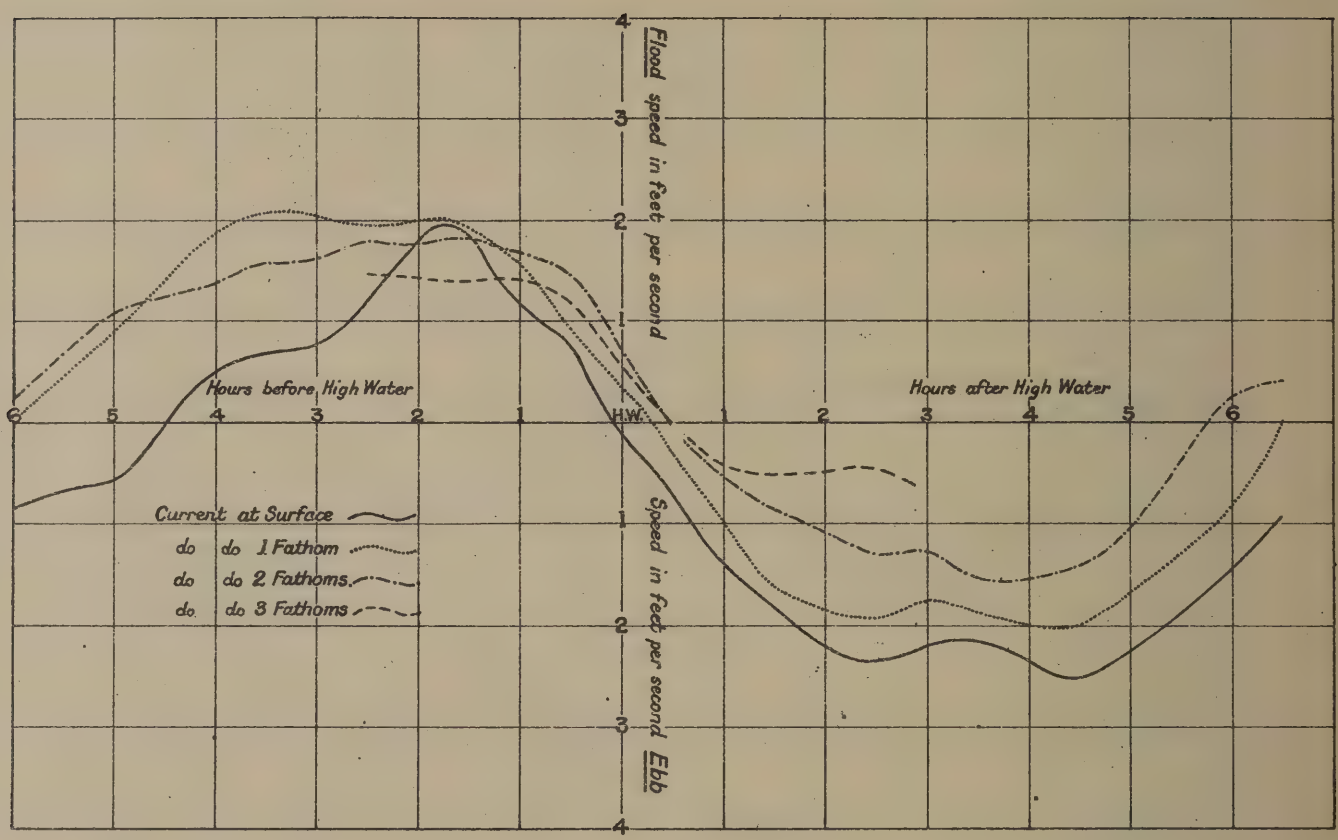


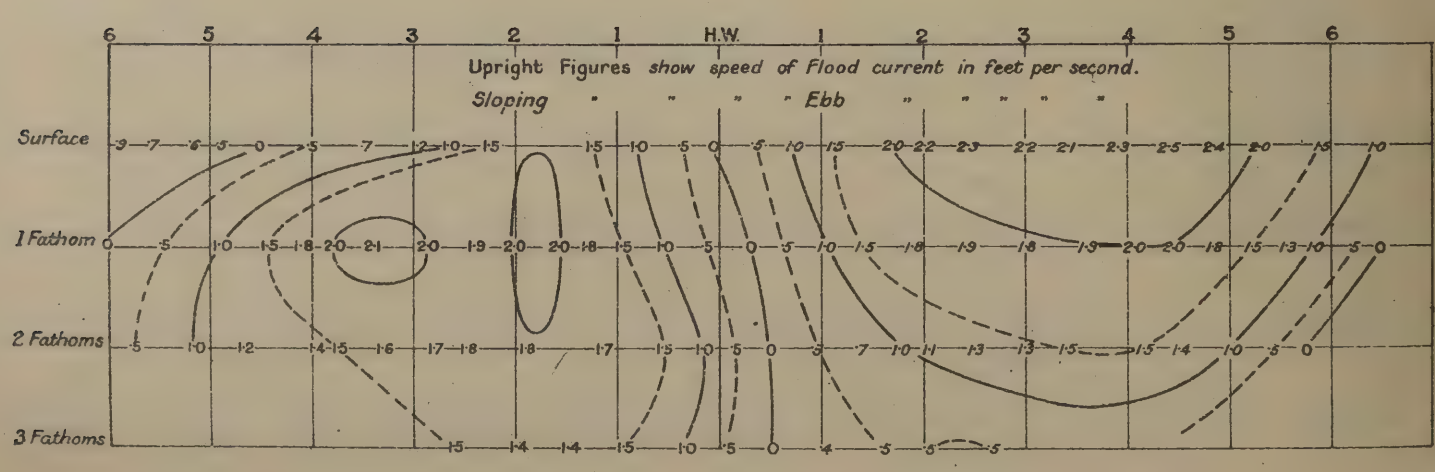


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT B.III.

Range 11 to 14 feet

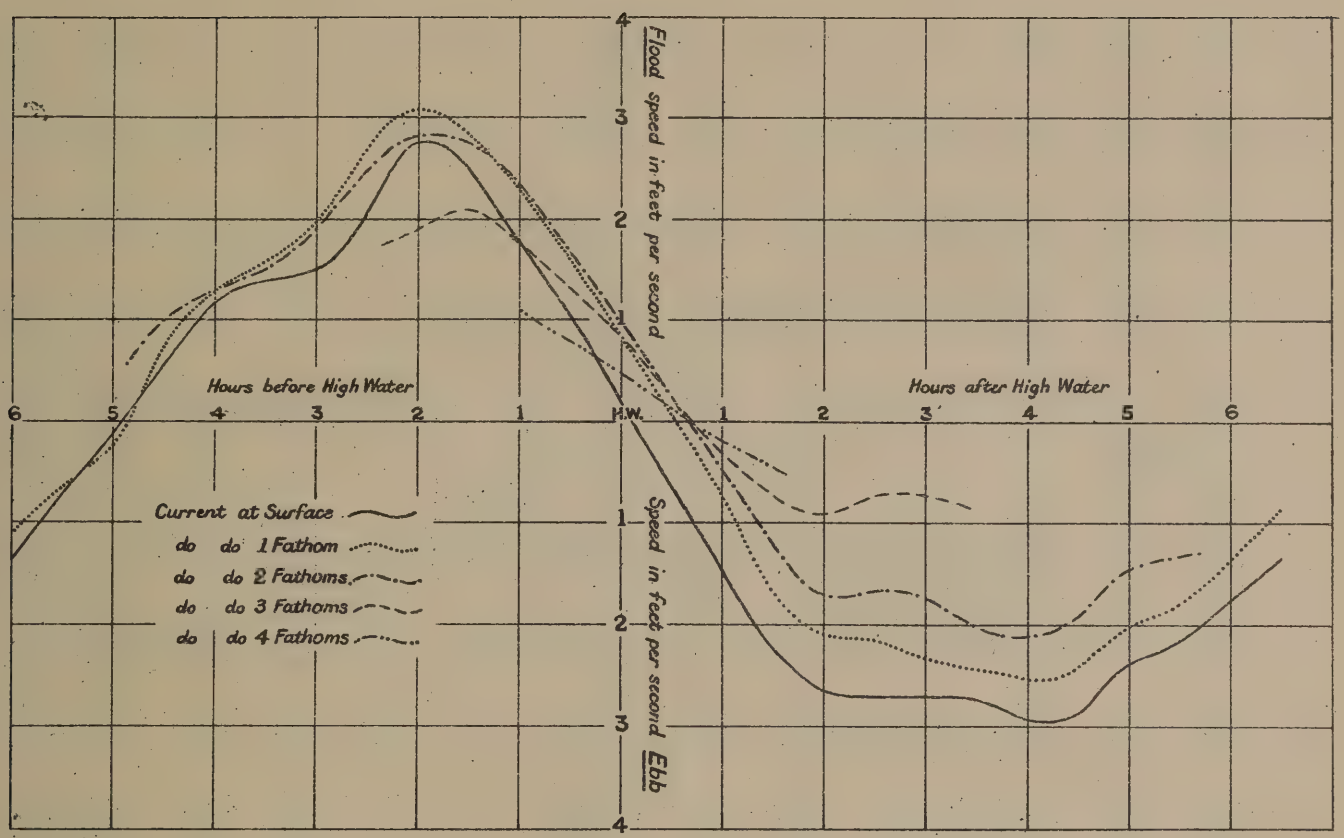


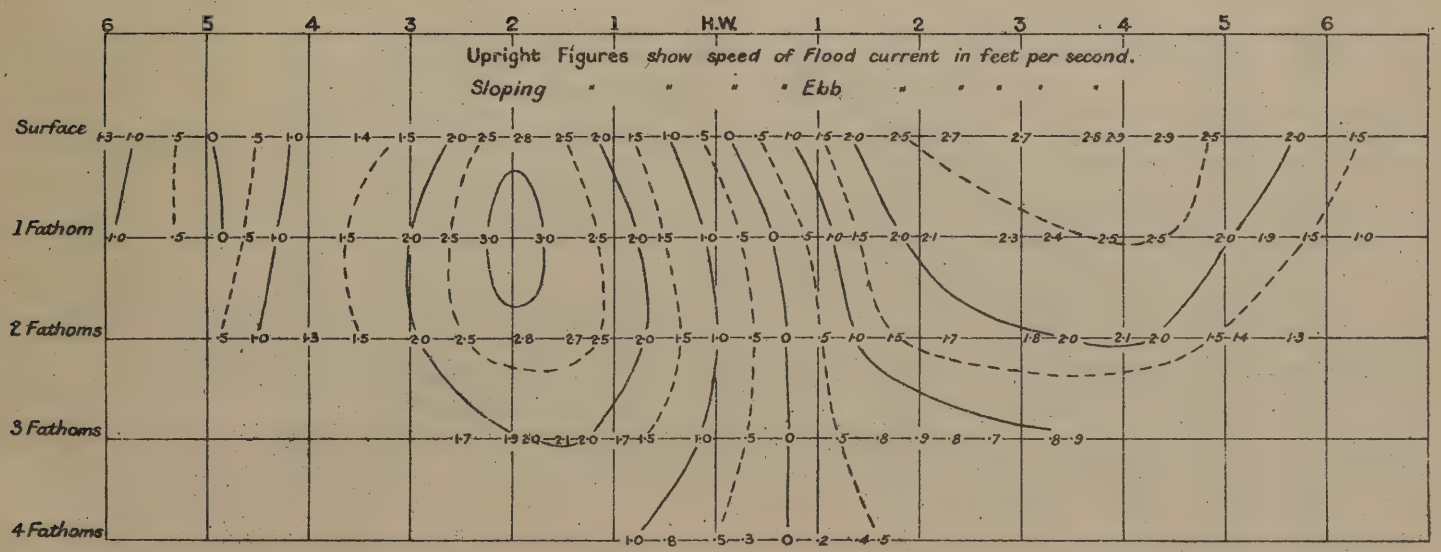


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT B.IV.

Range - Above 14 feet

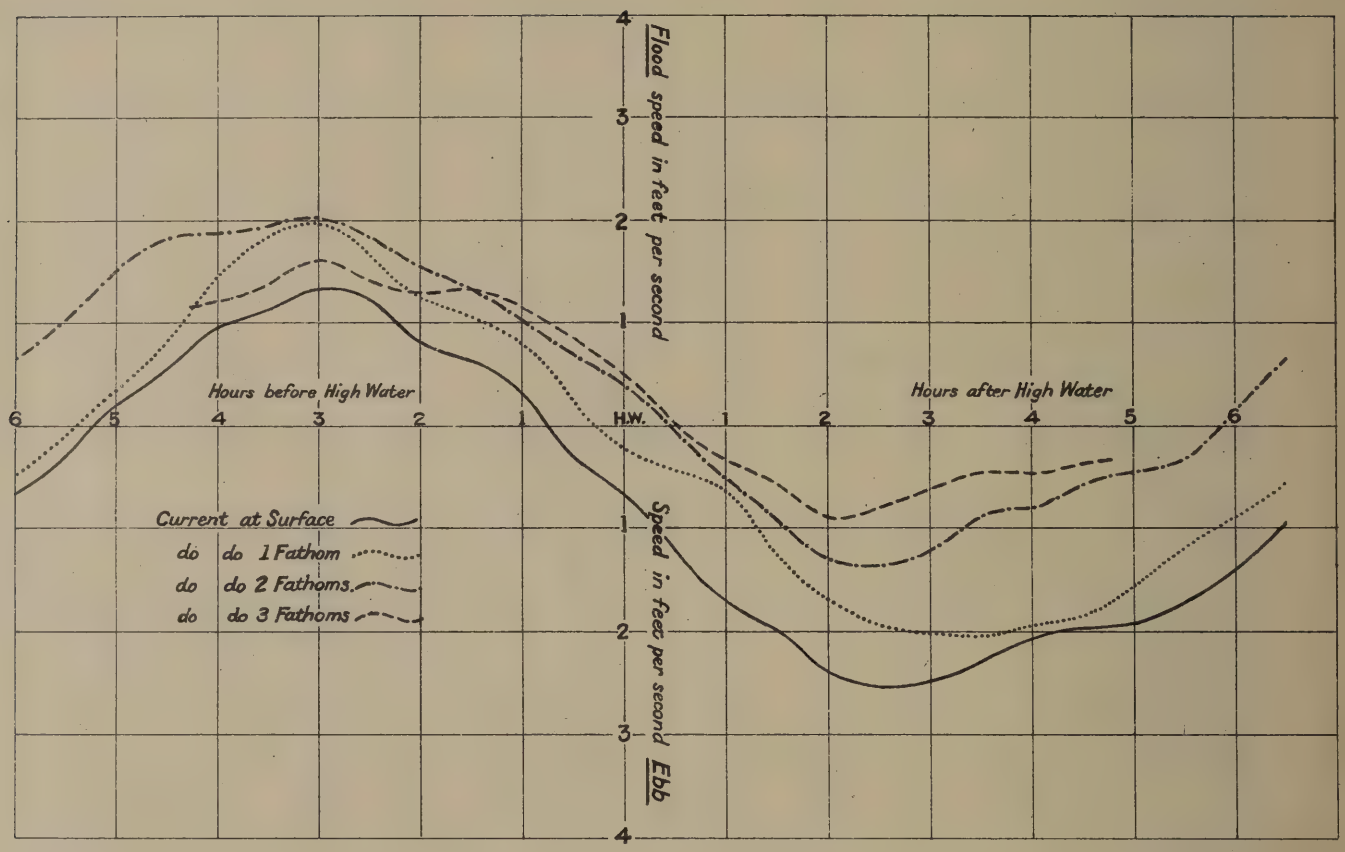


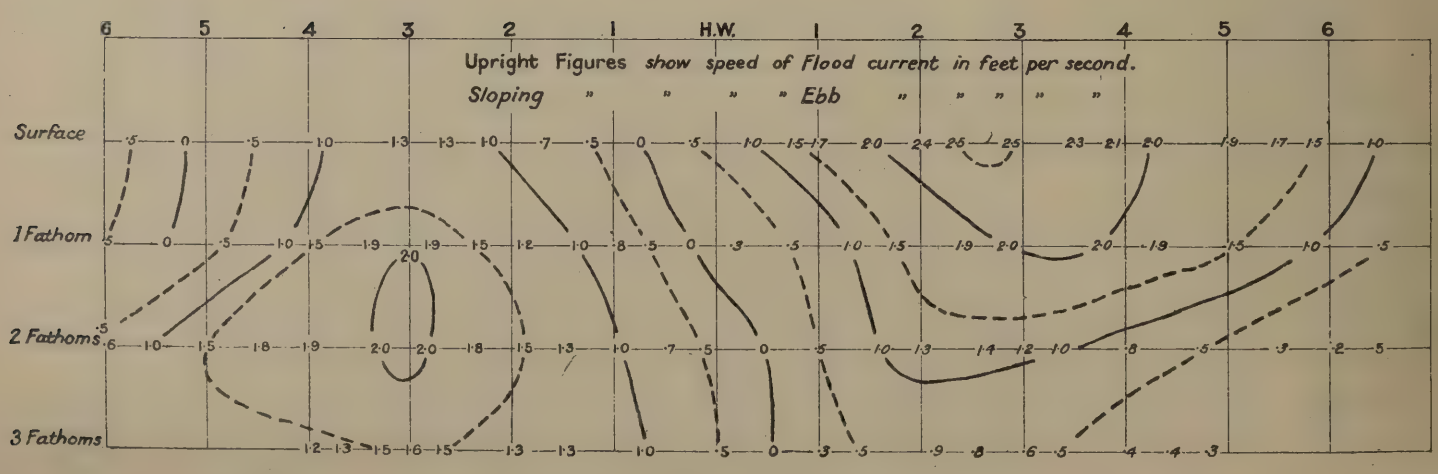


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT C.I.

Range Below 8 feet

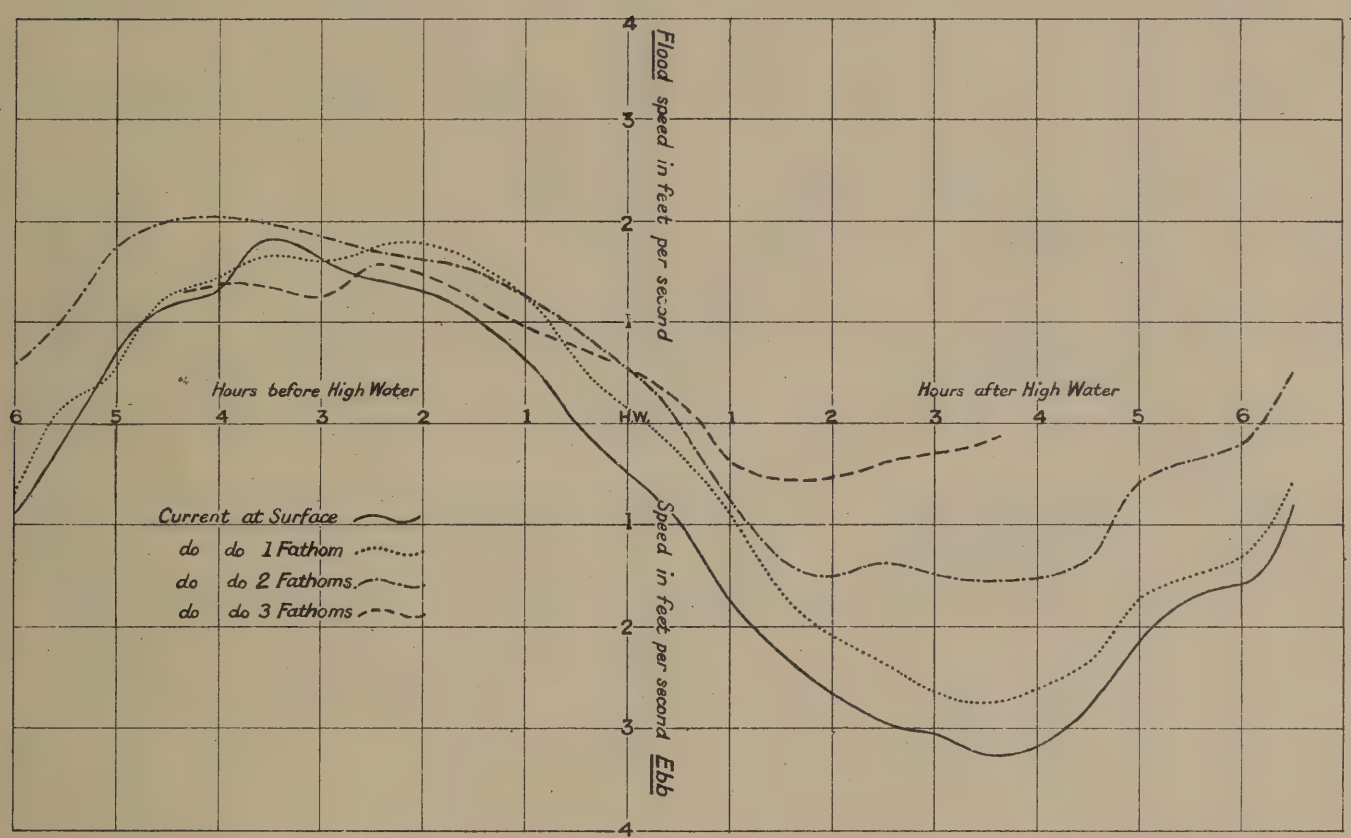


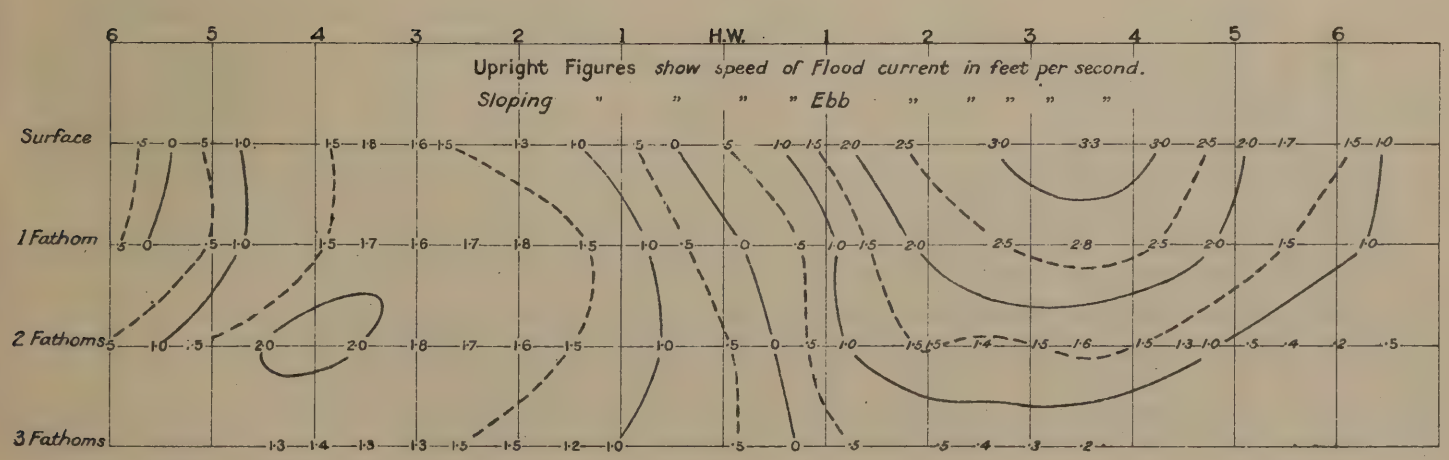


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT C.II.

Range 8 to 11 feet

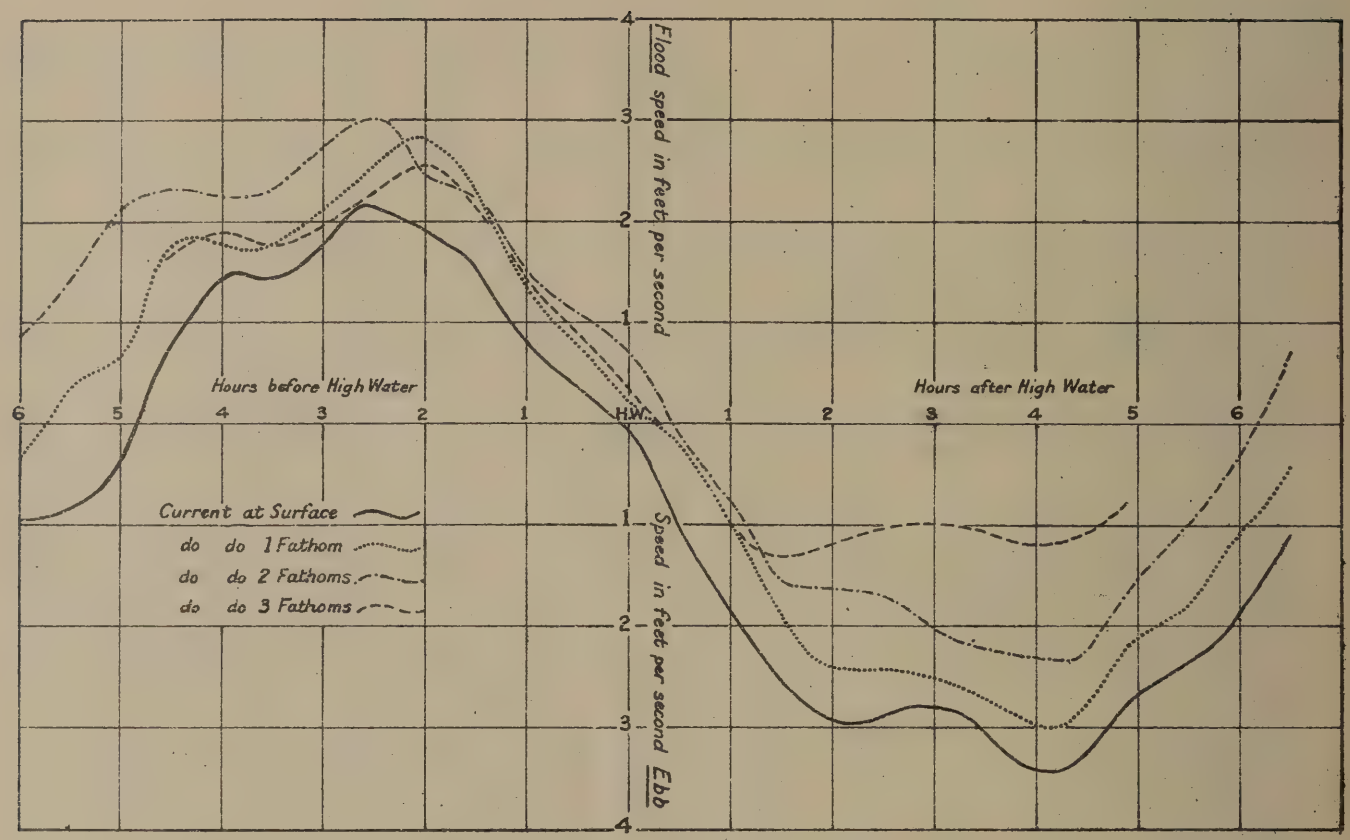


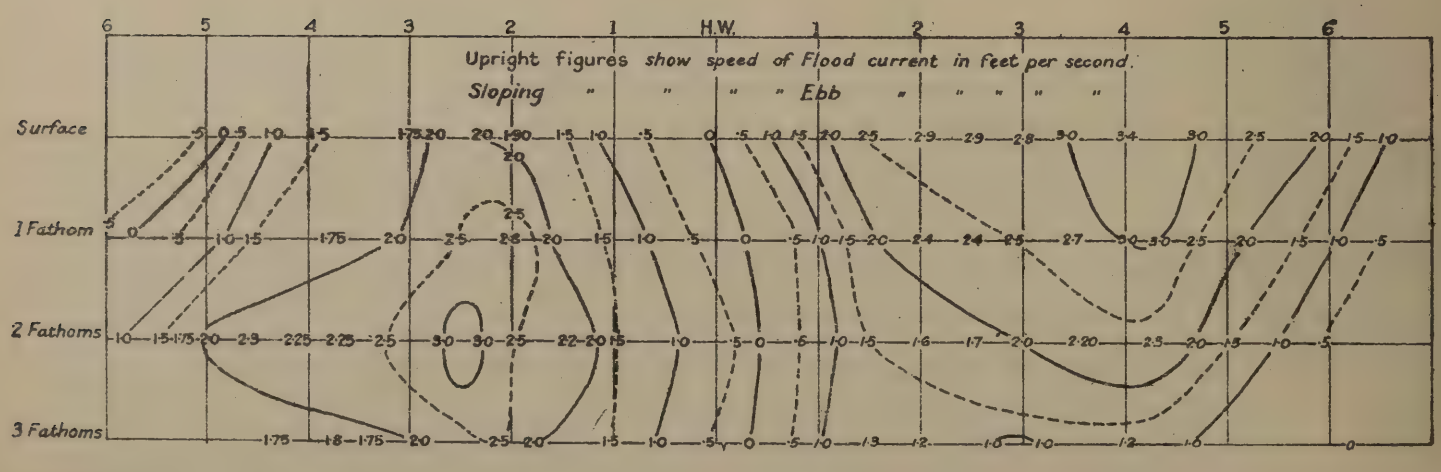


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT C.III.

Range 11 to 14 feet

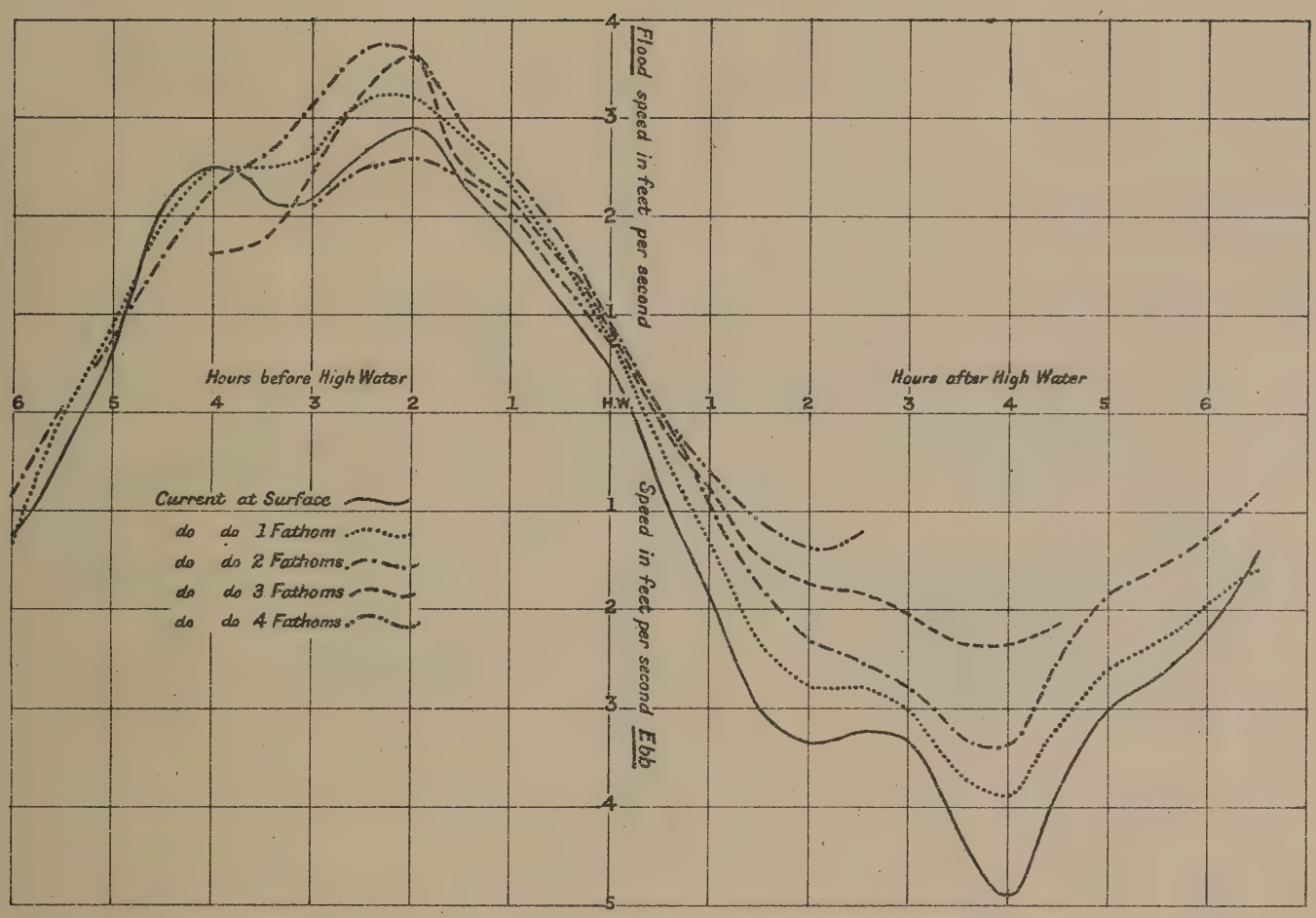


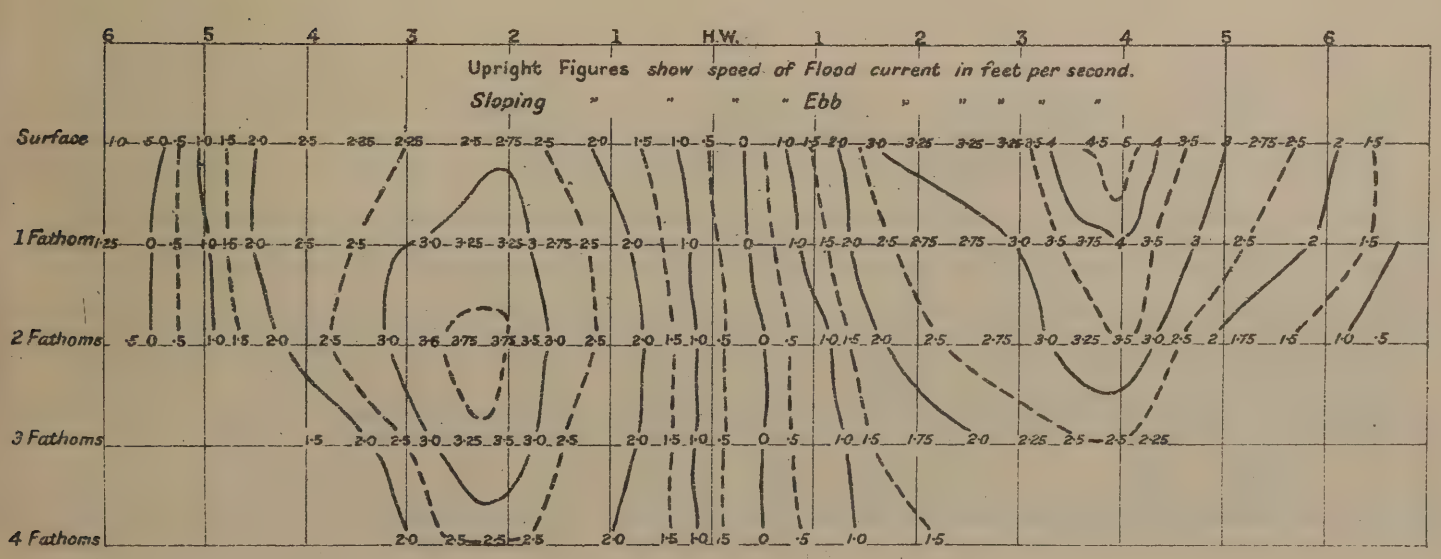


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT C.IV.

Range - Above 14 feet

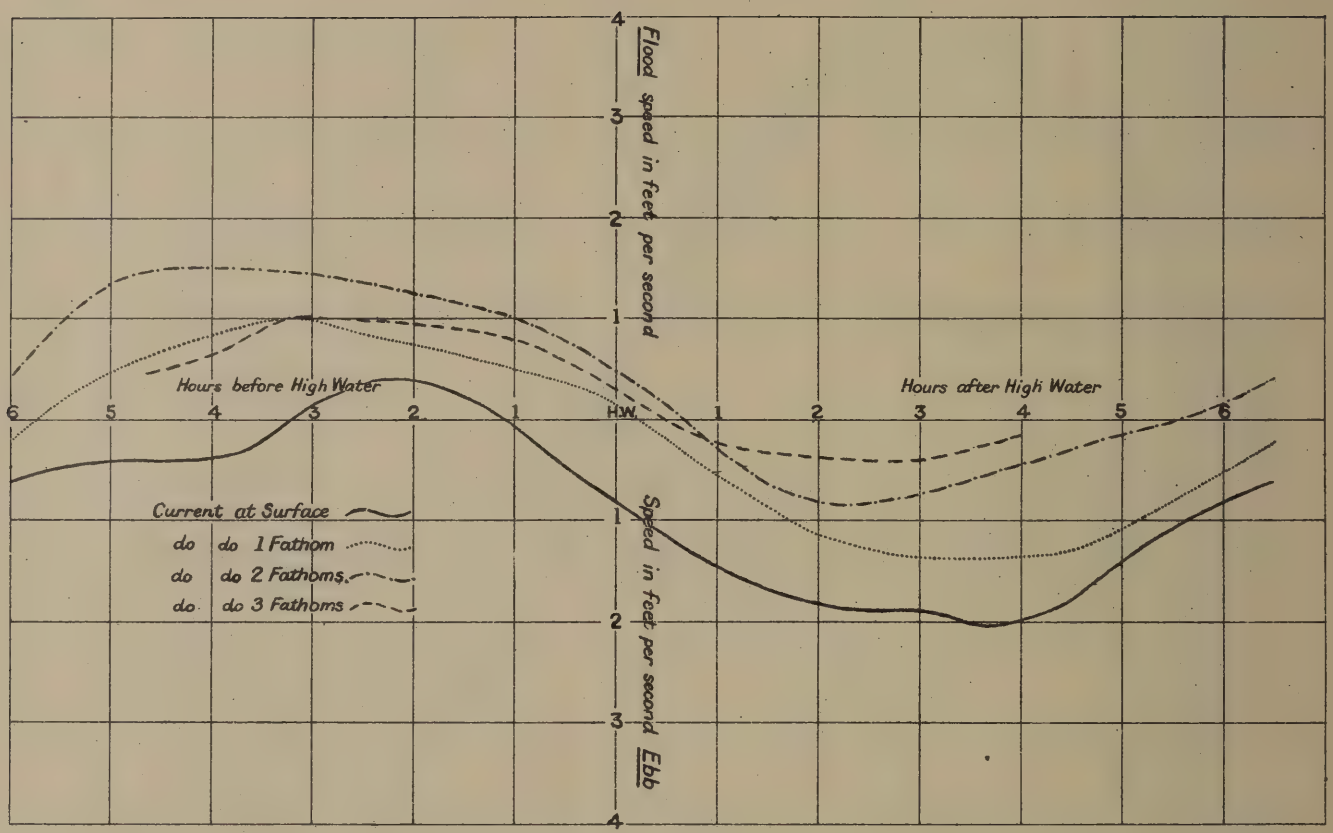


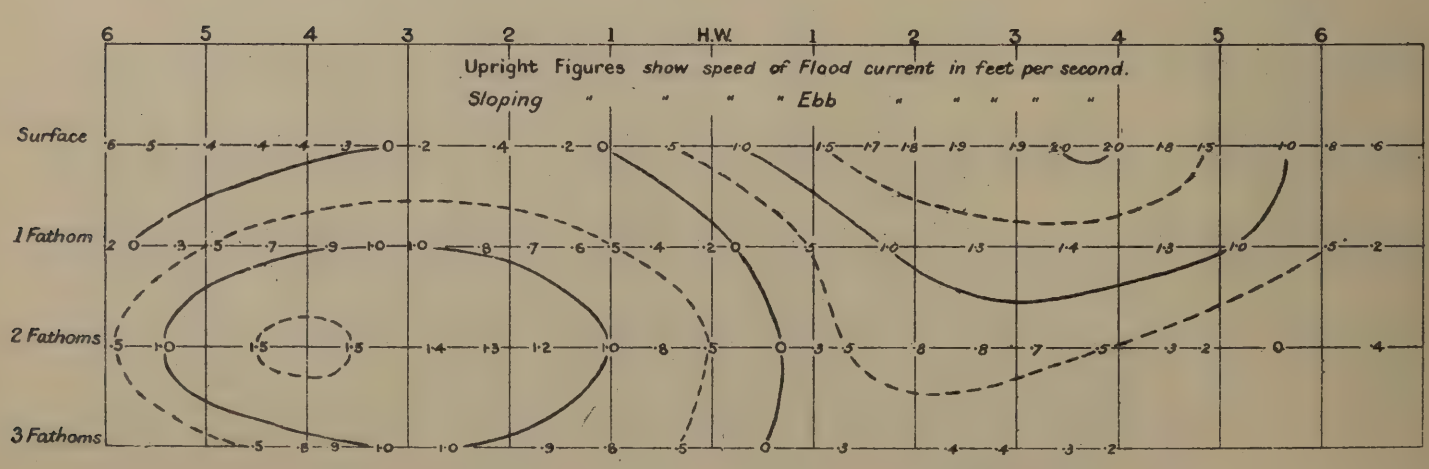


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT D.I.

Range - Below 8 feet

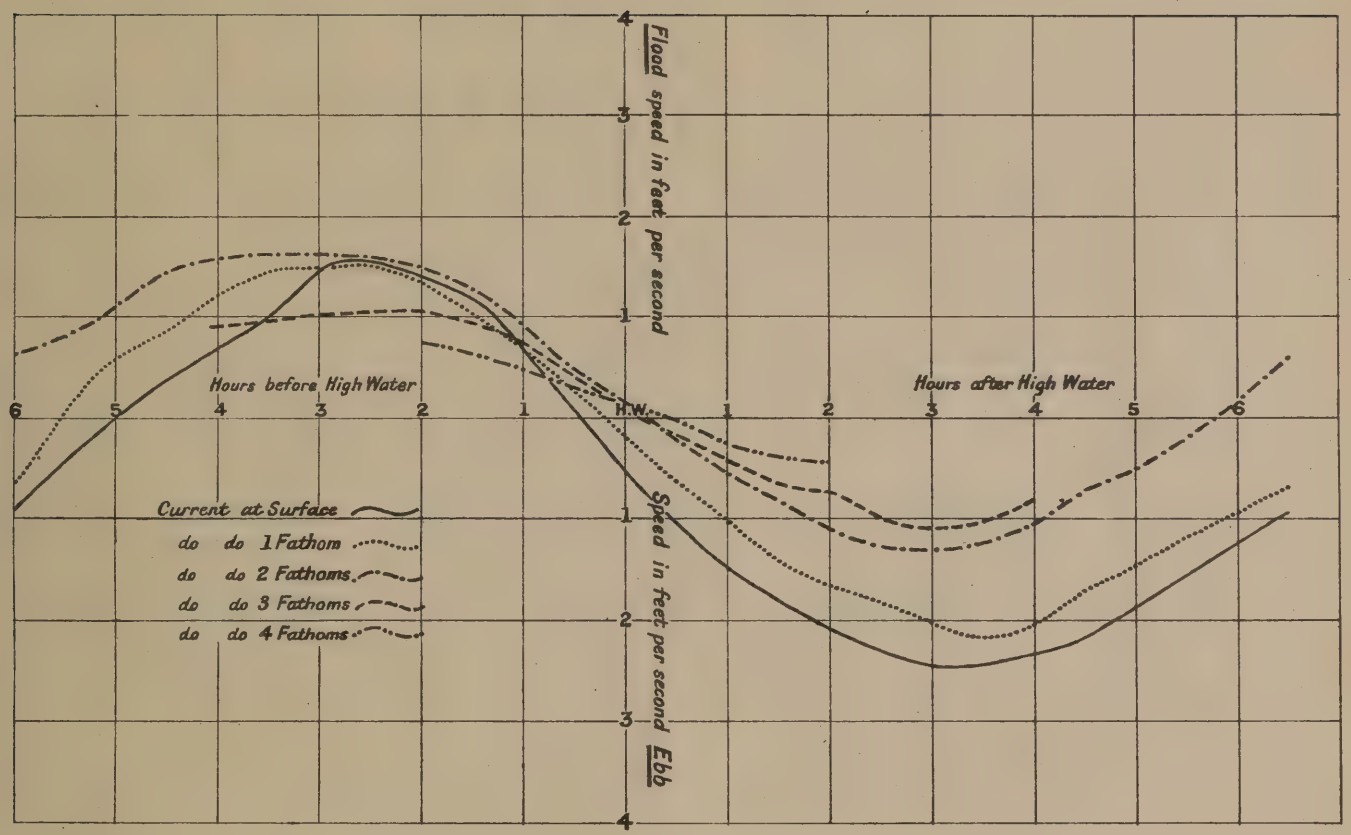


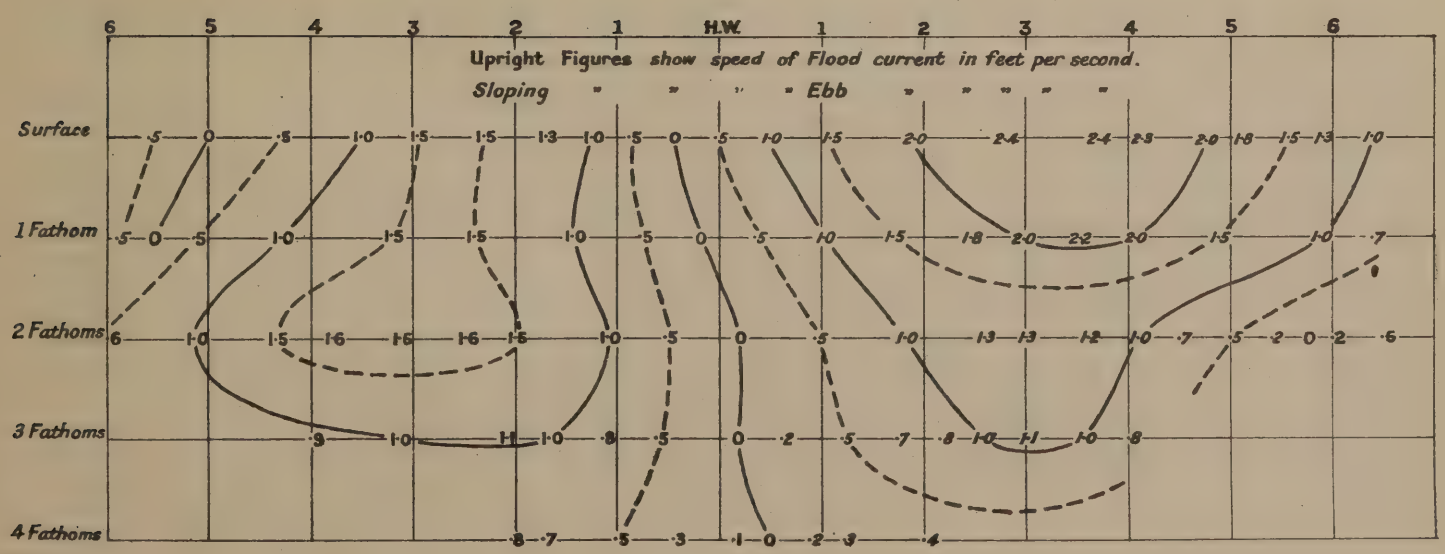


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT D.II.

Range 8 to 11 feet

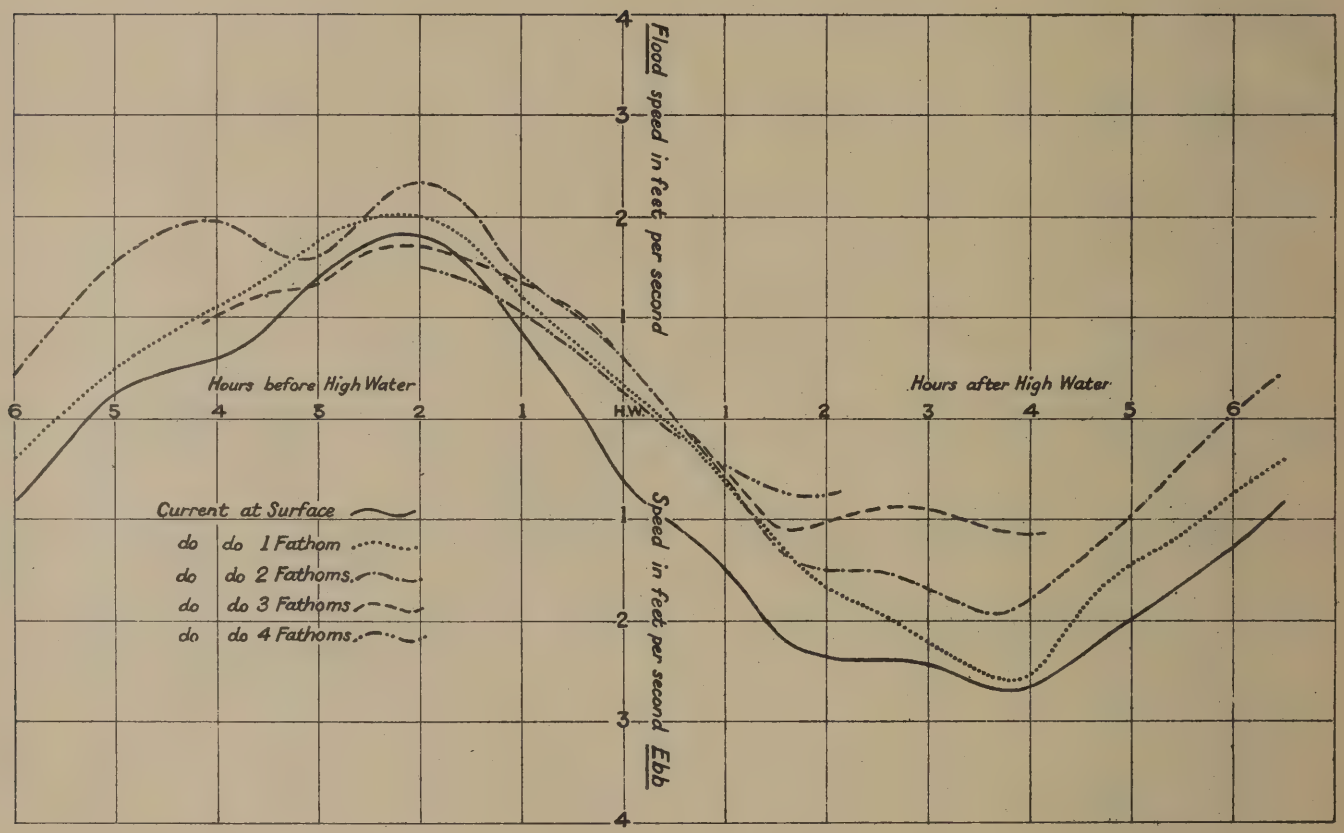


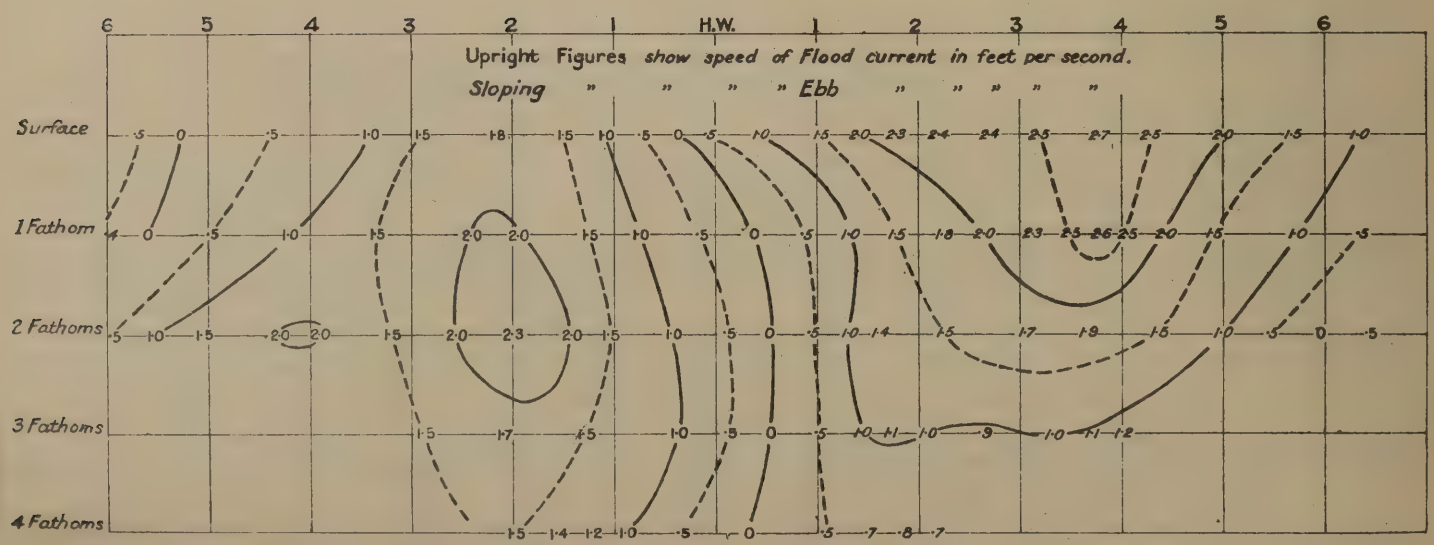


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT D.III.

Range 11 to 14 feet





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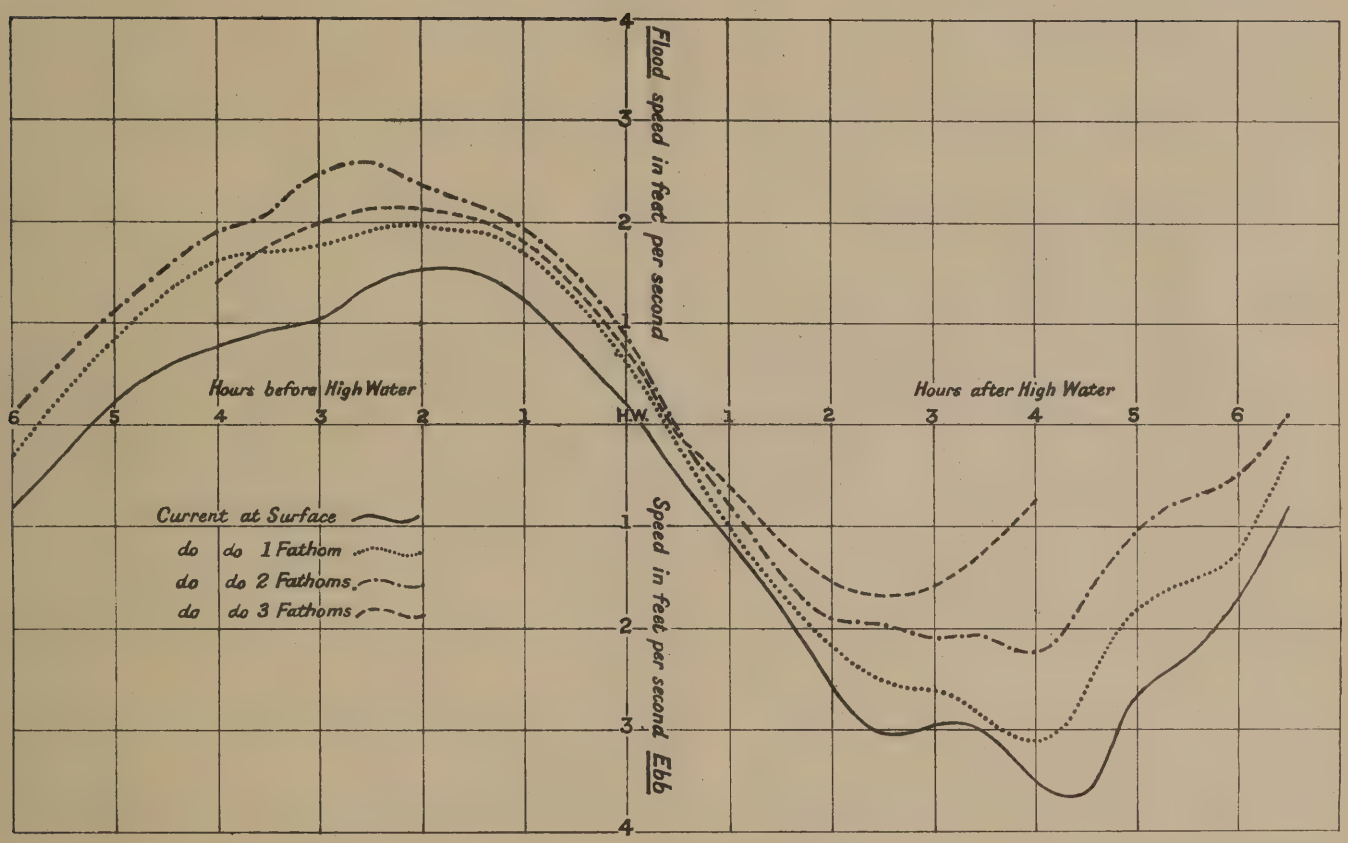
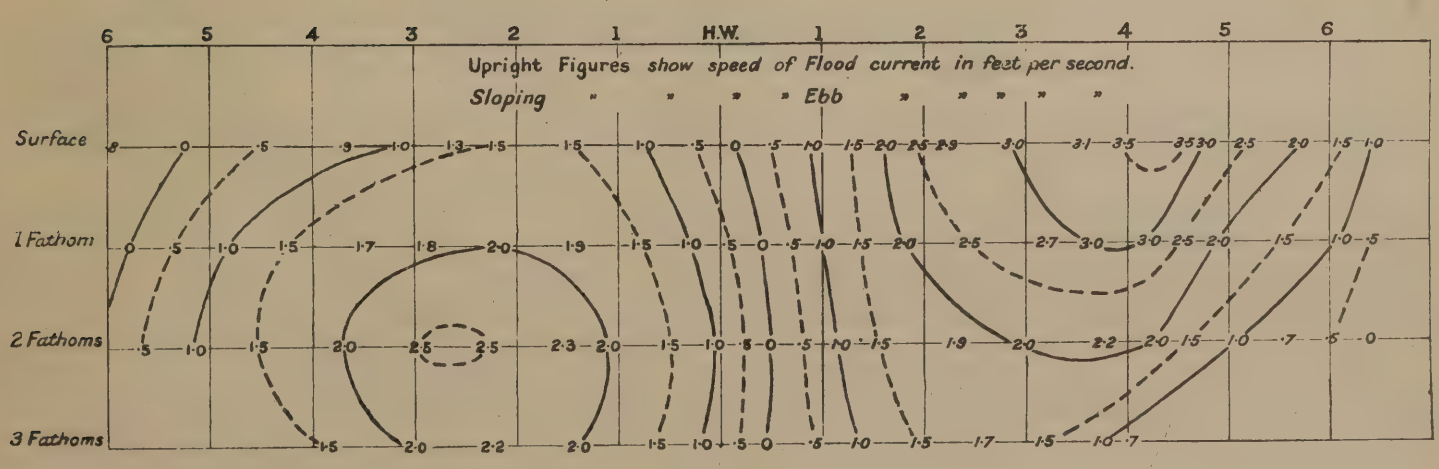
RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT D.IV.

Range - Above 14 feet

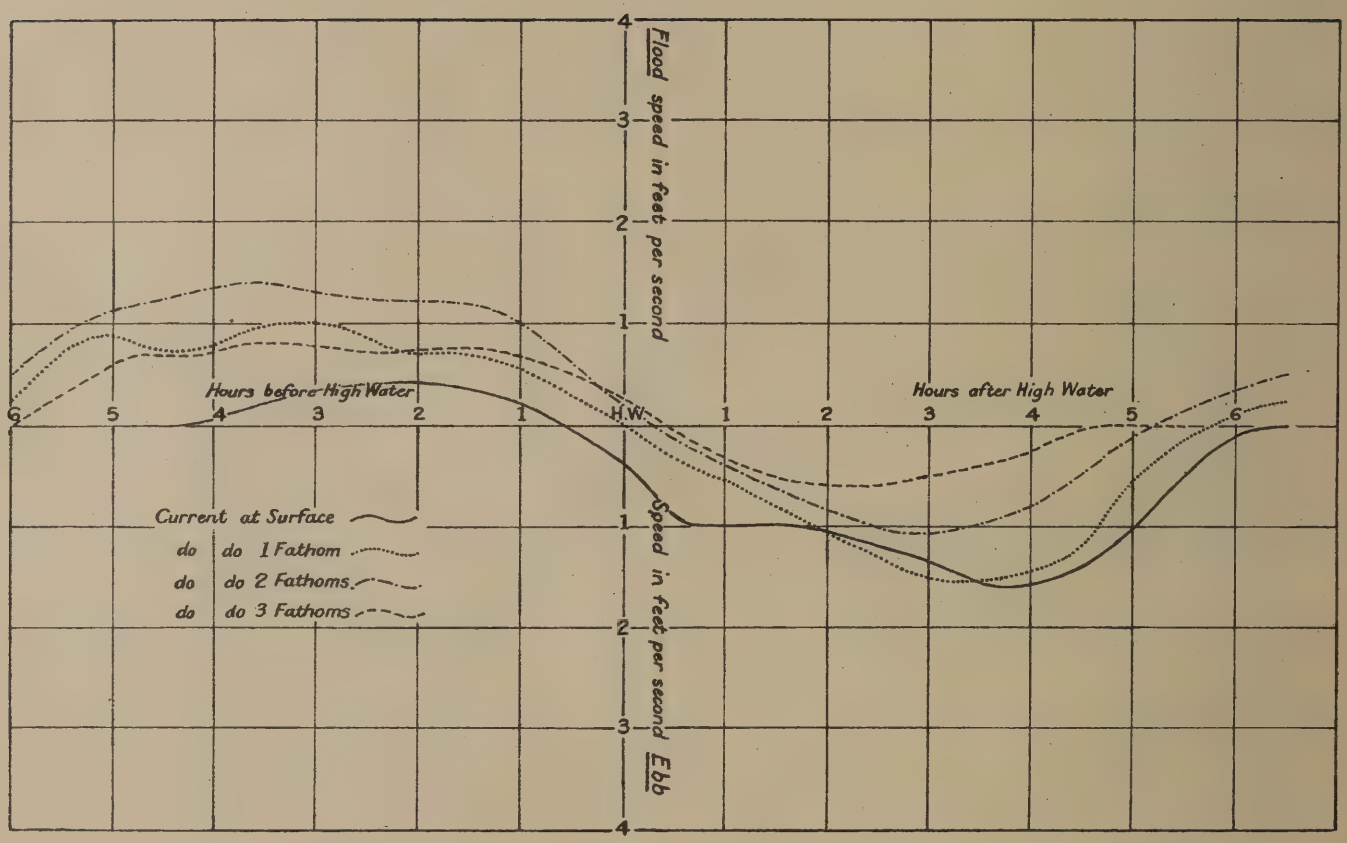


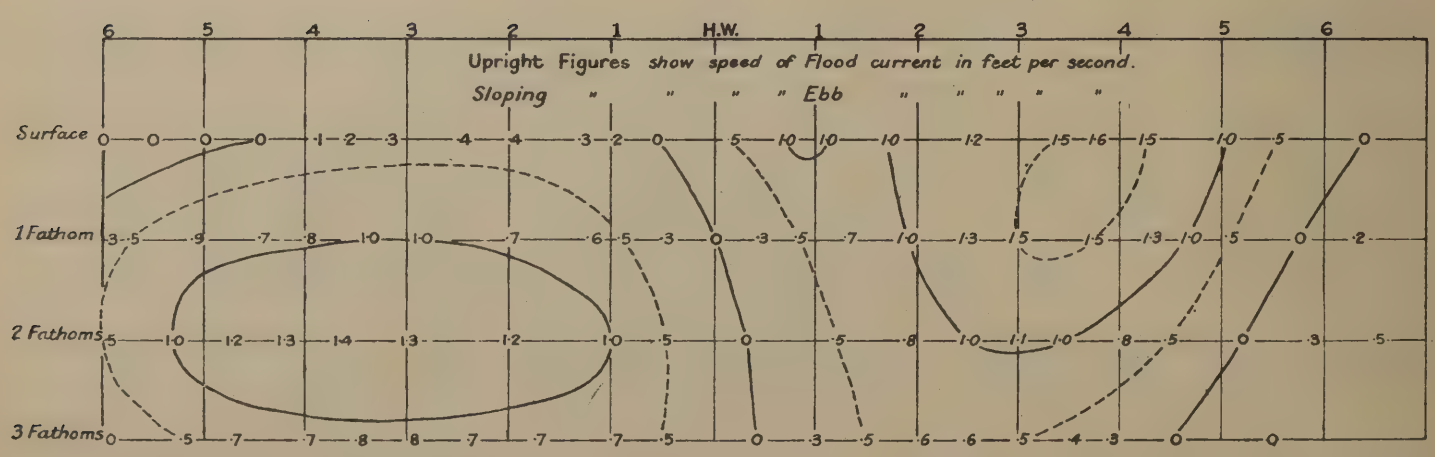


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT E I

Range - Below 8 feet

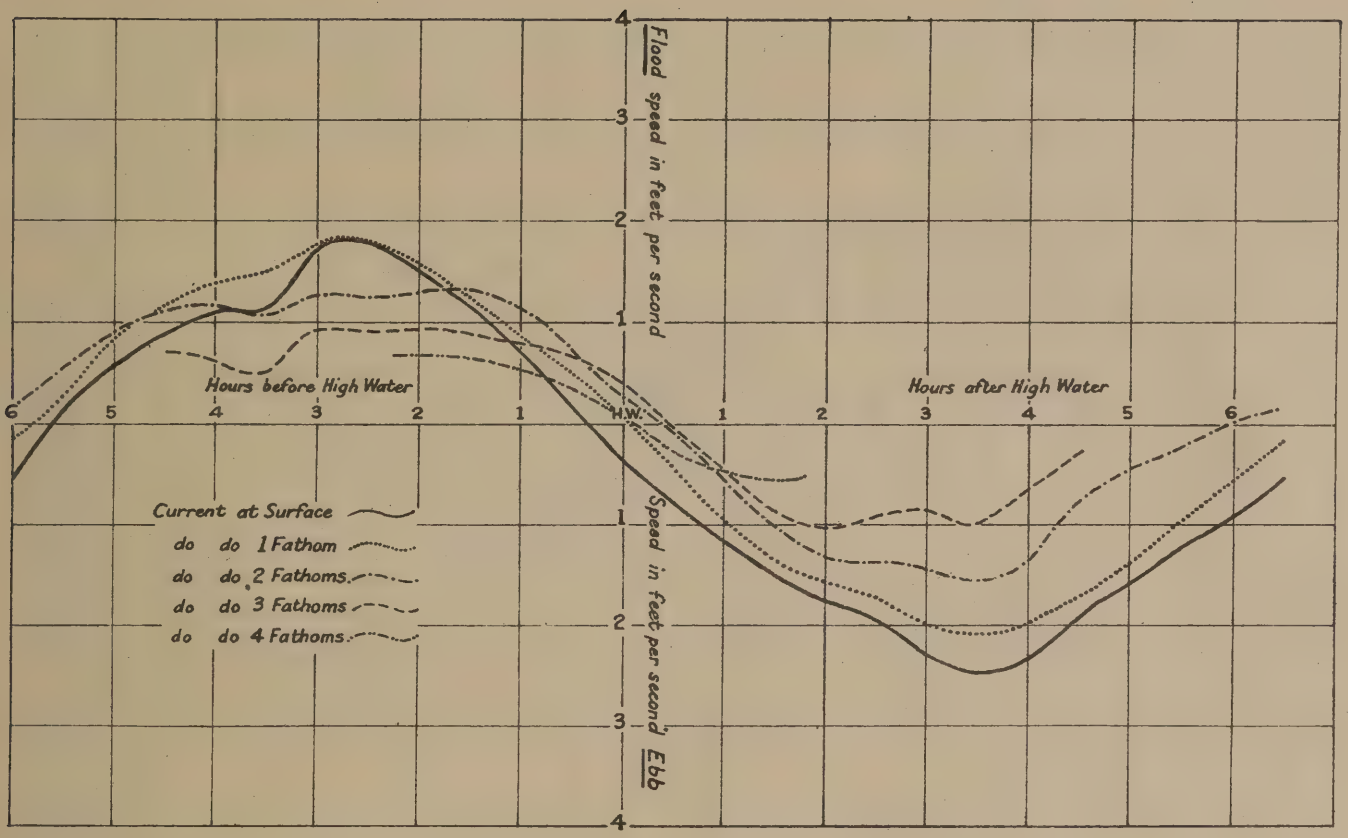


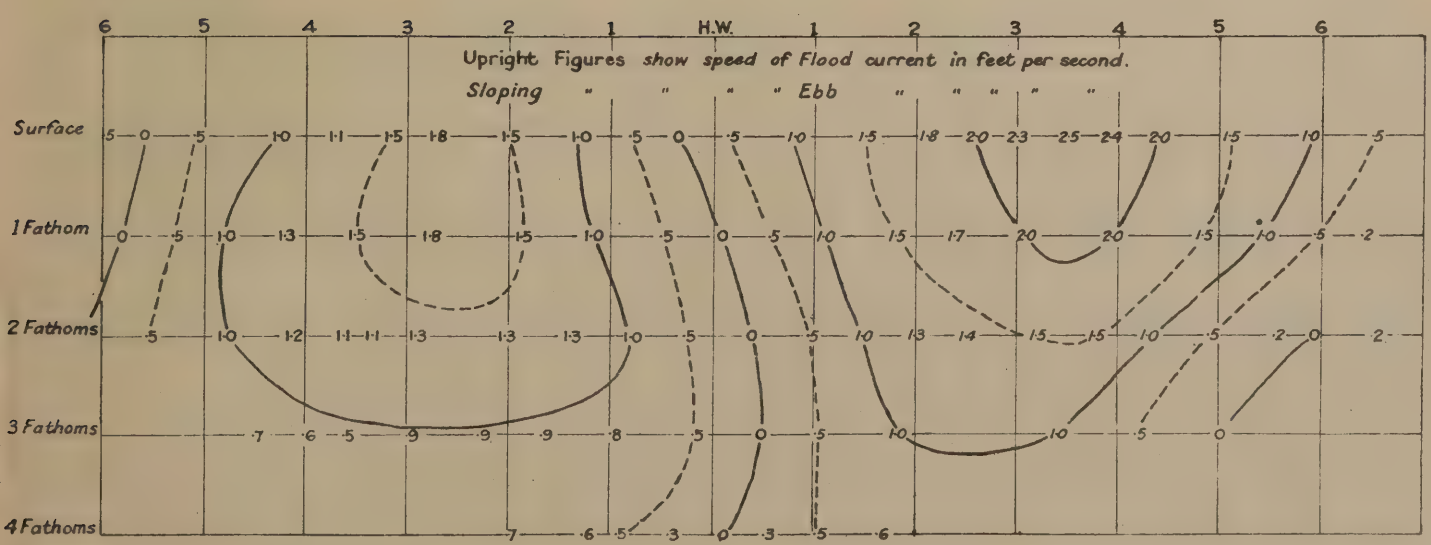


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT E. II.

Range 8 to 11 feet

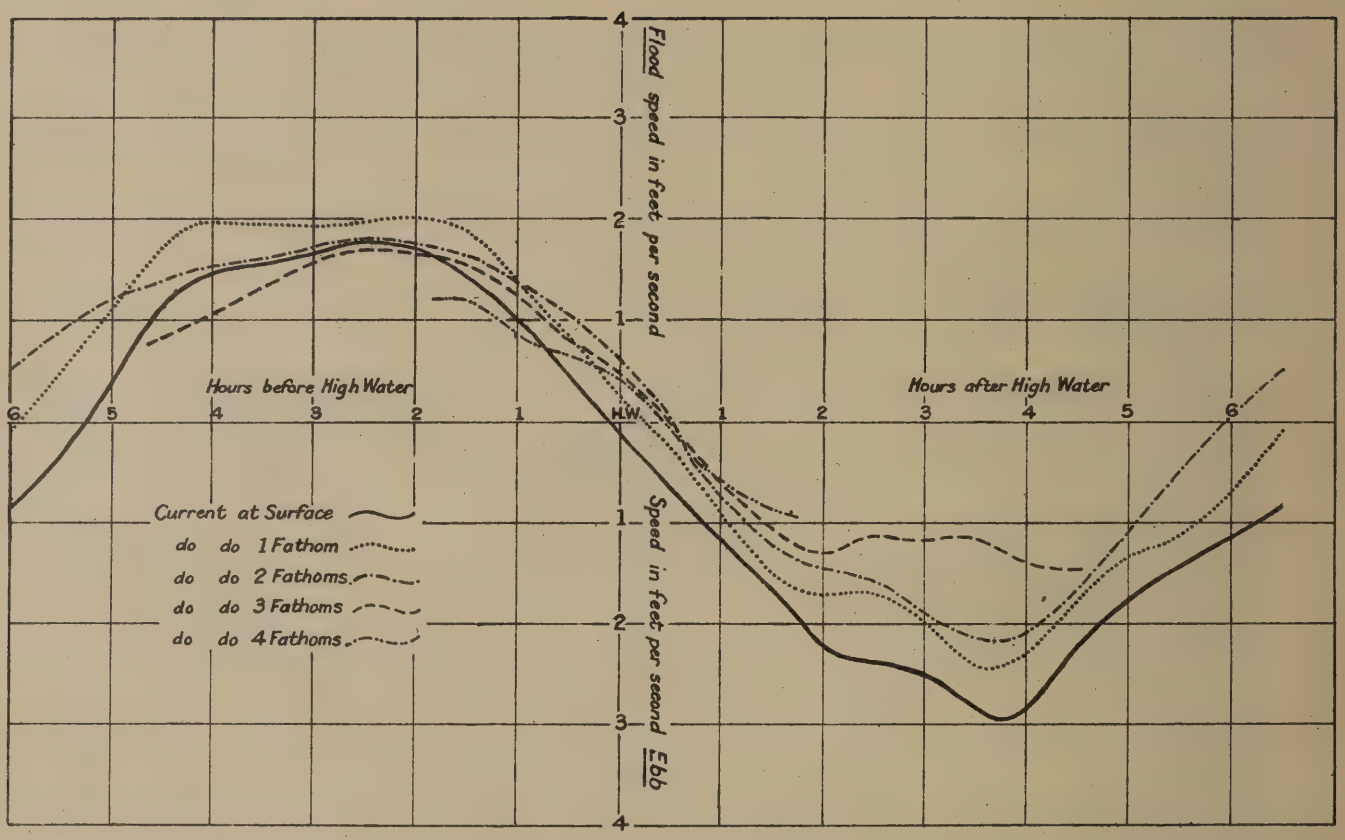


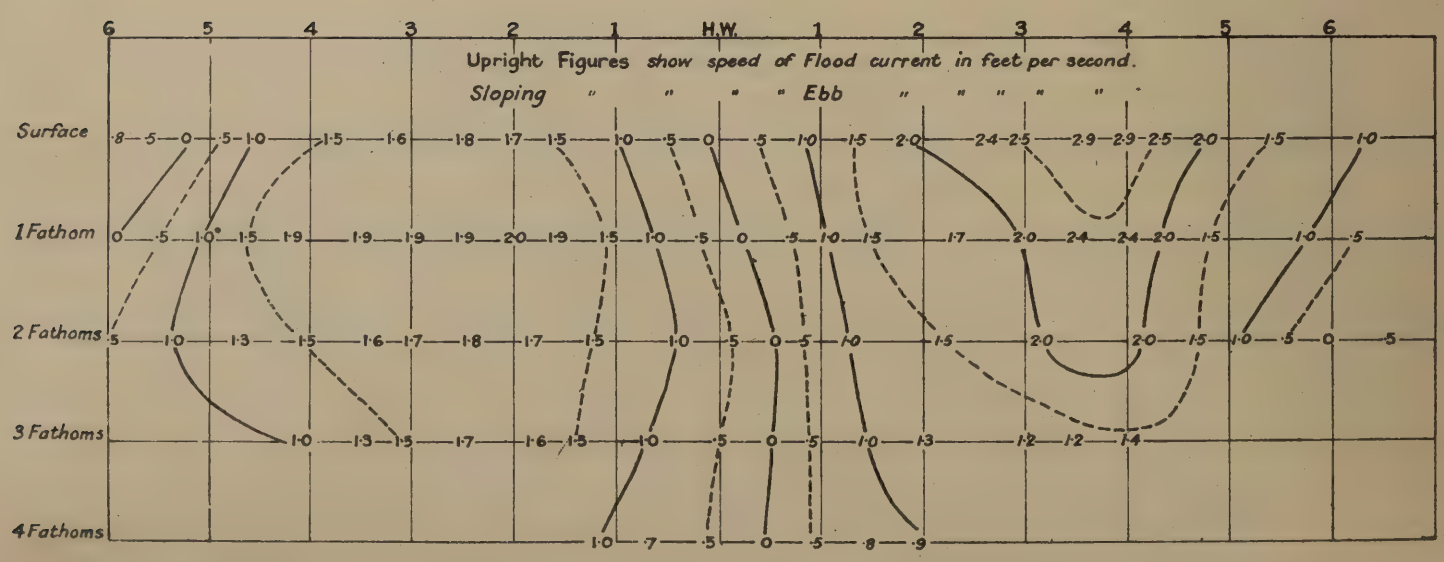


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT E.III.

Range 11 to 14 feet

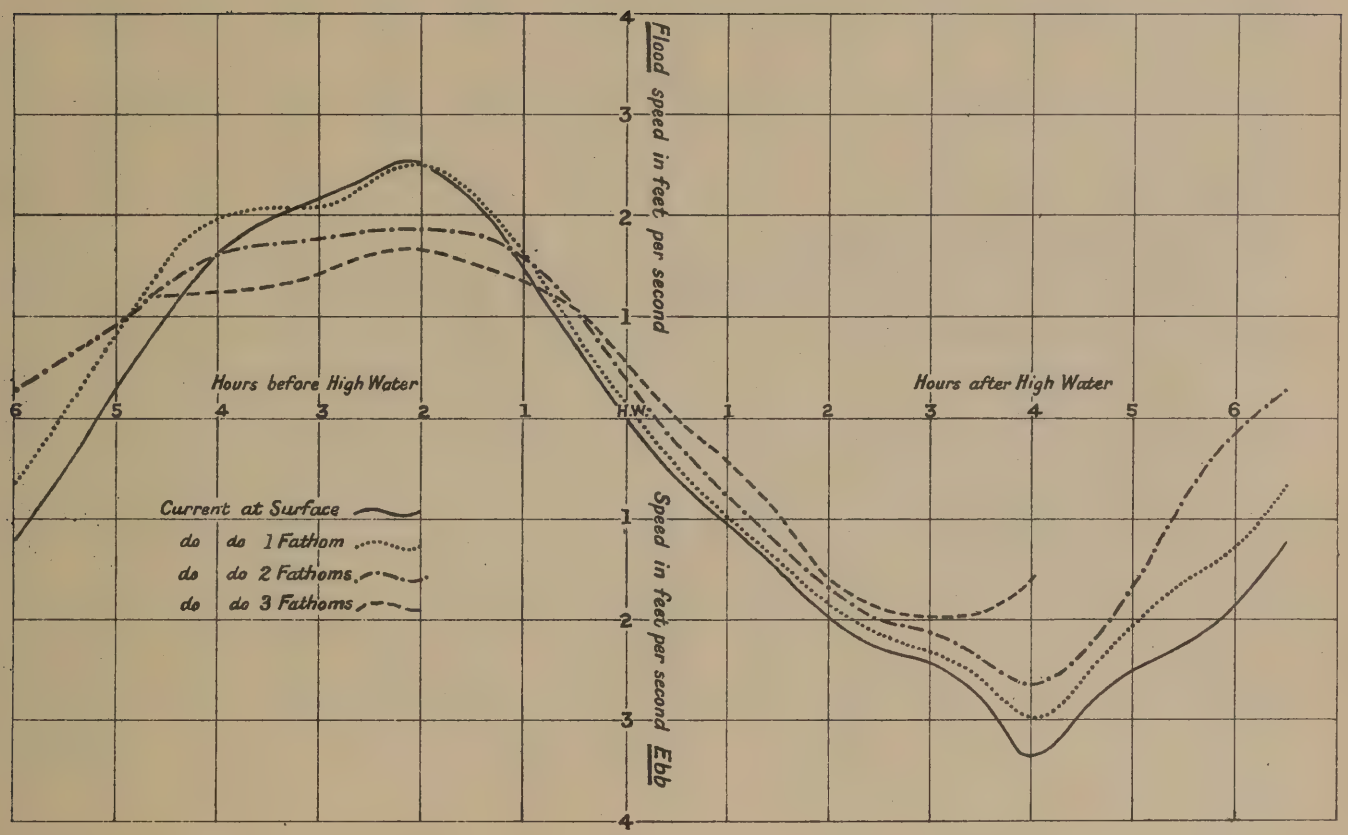


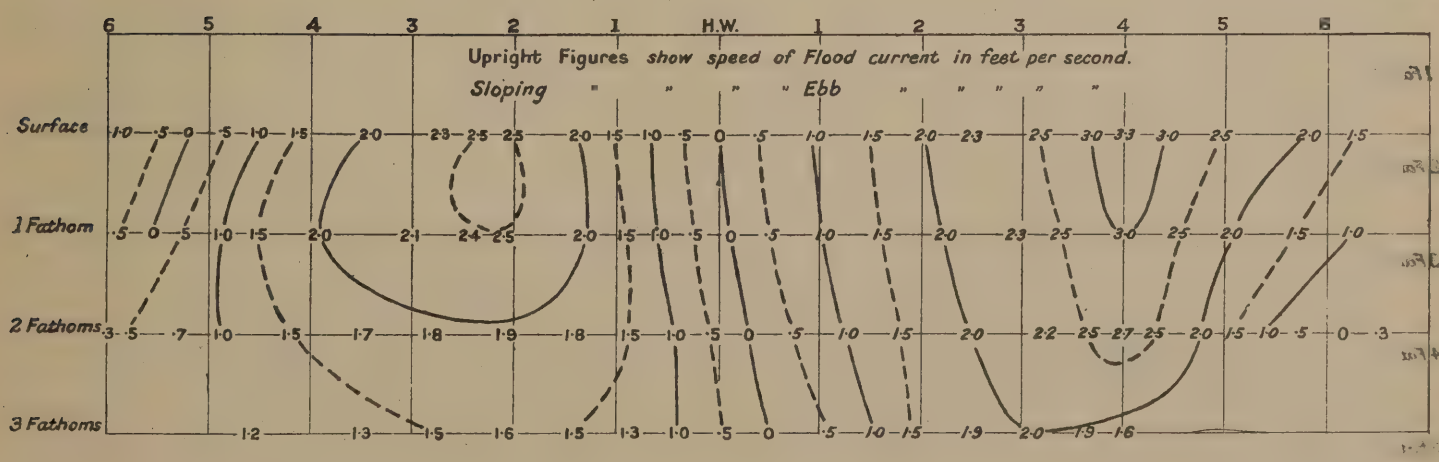


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT E.IV

Range - Above 14 feet

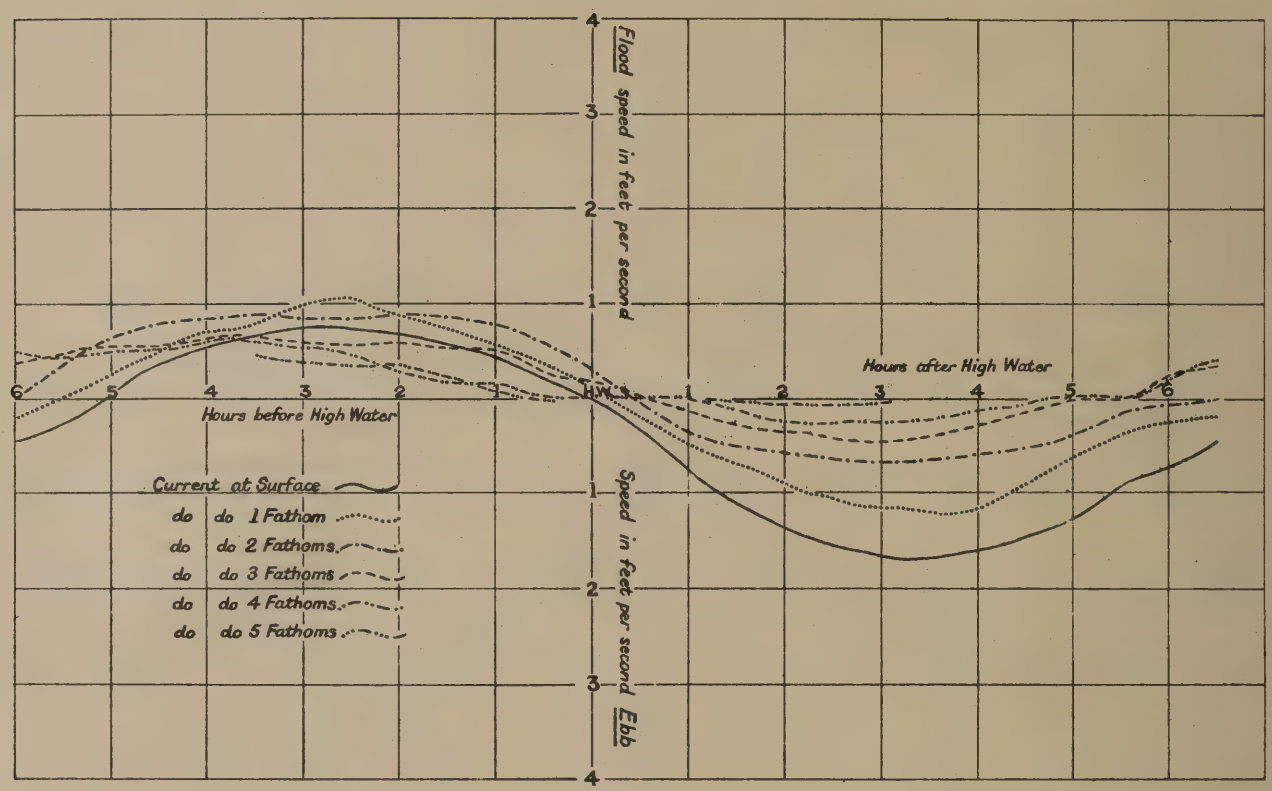


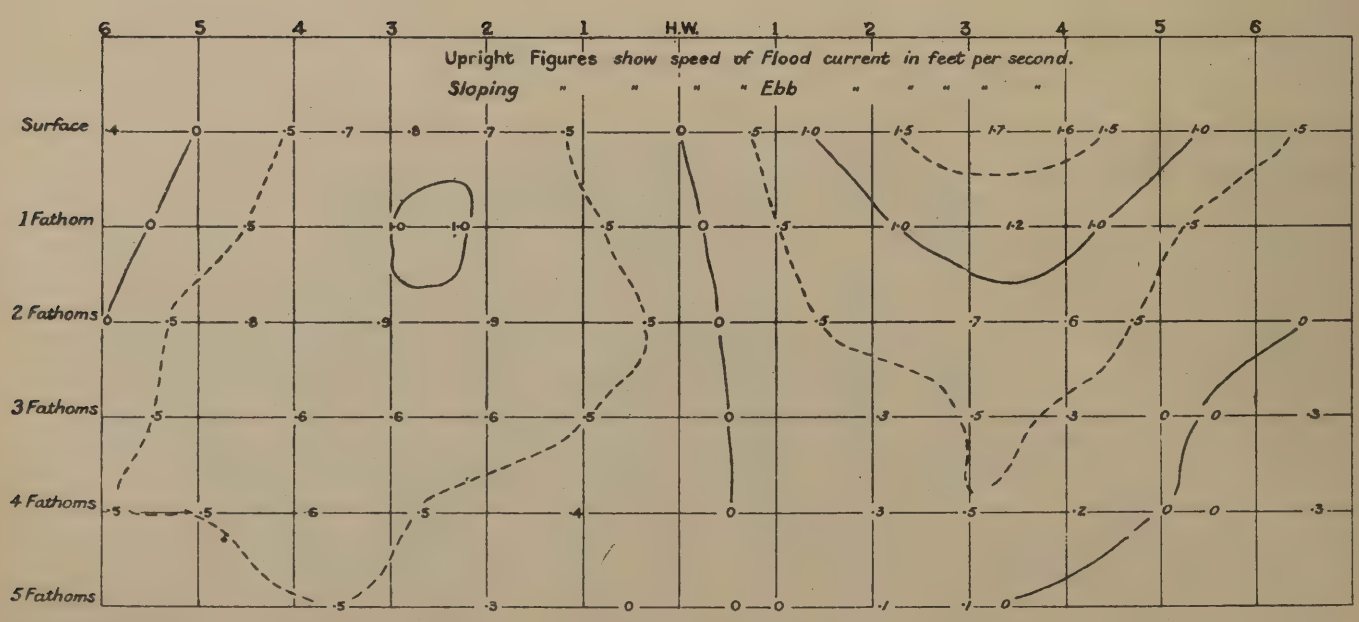


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT F.I.

Range 8 feet and below

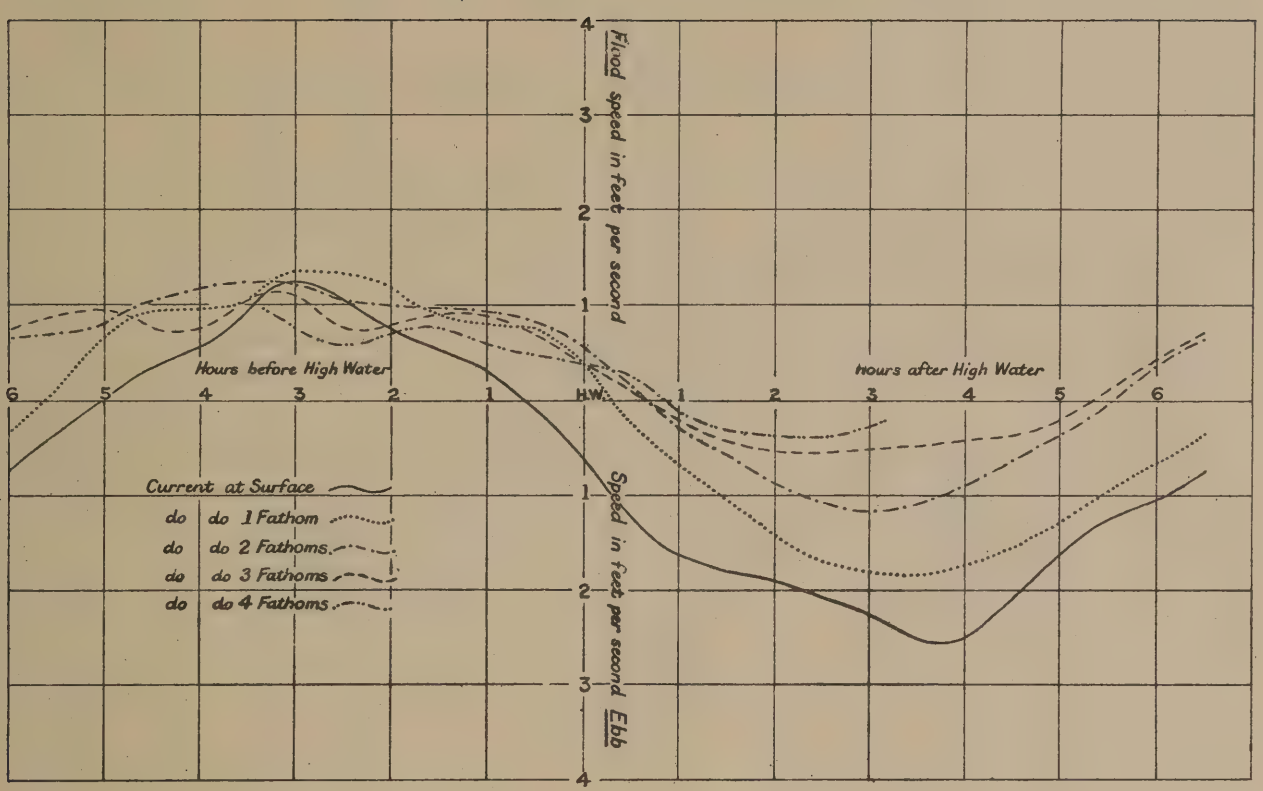


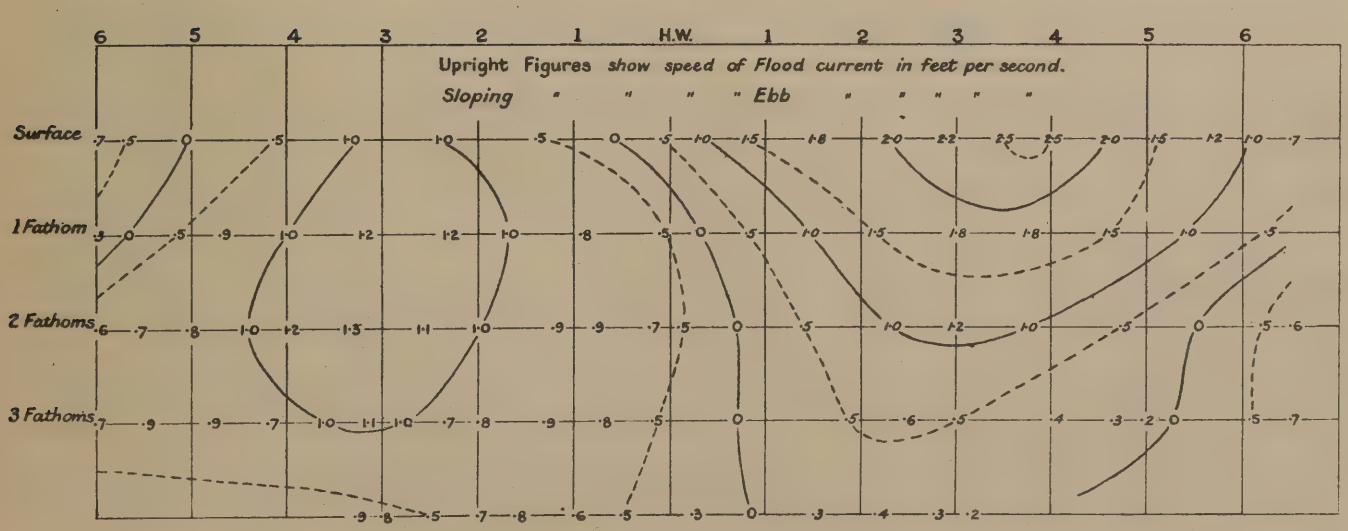


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT F. II.

Range - 8 to 11 feet





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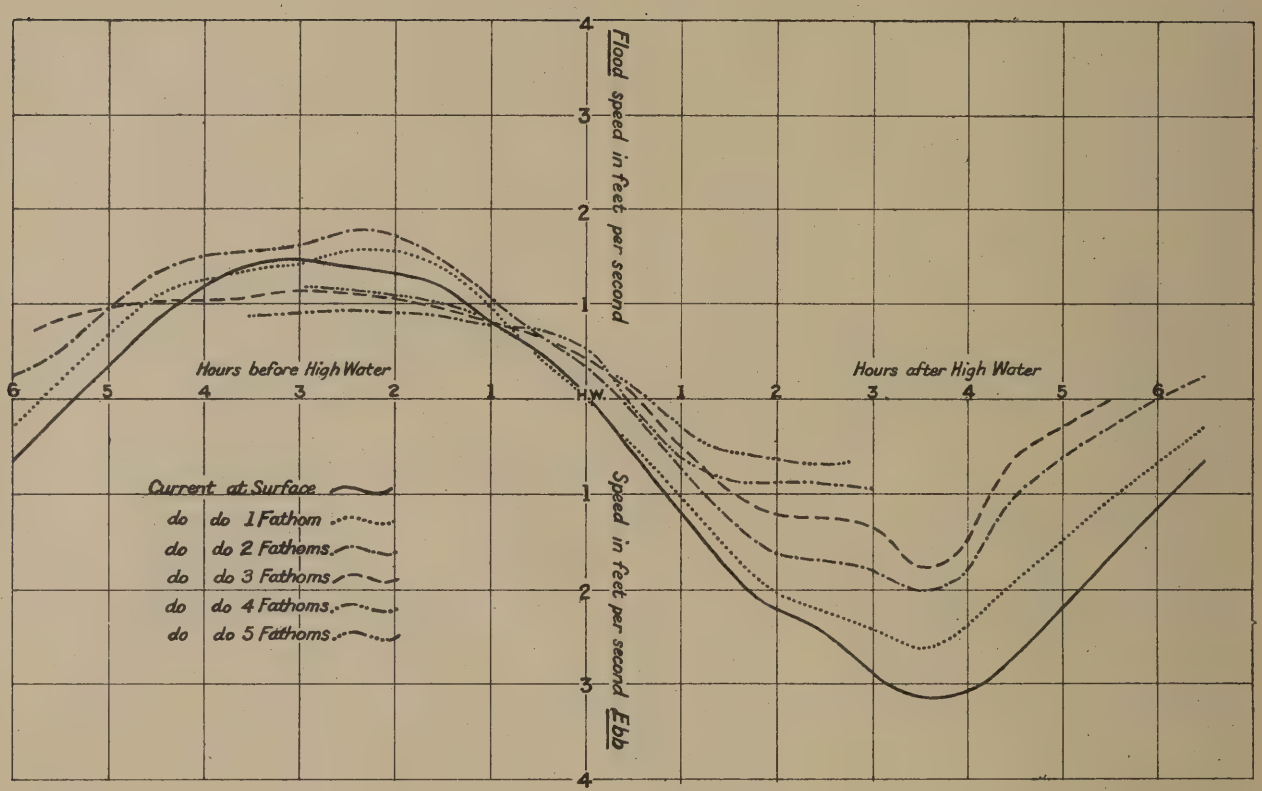
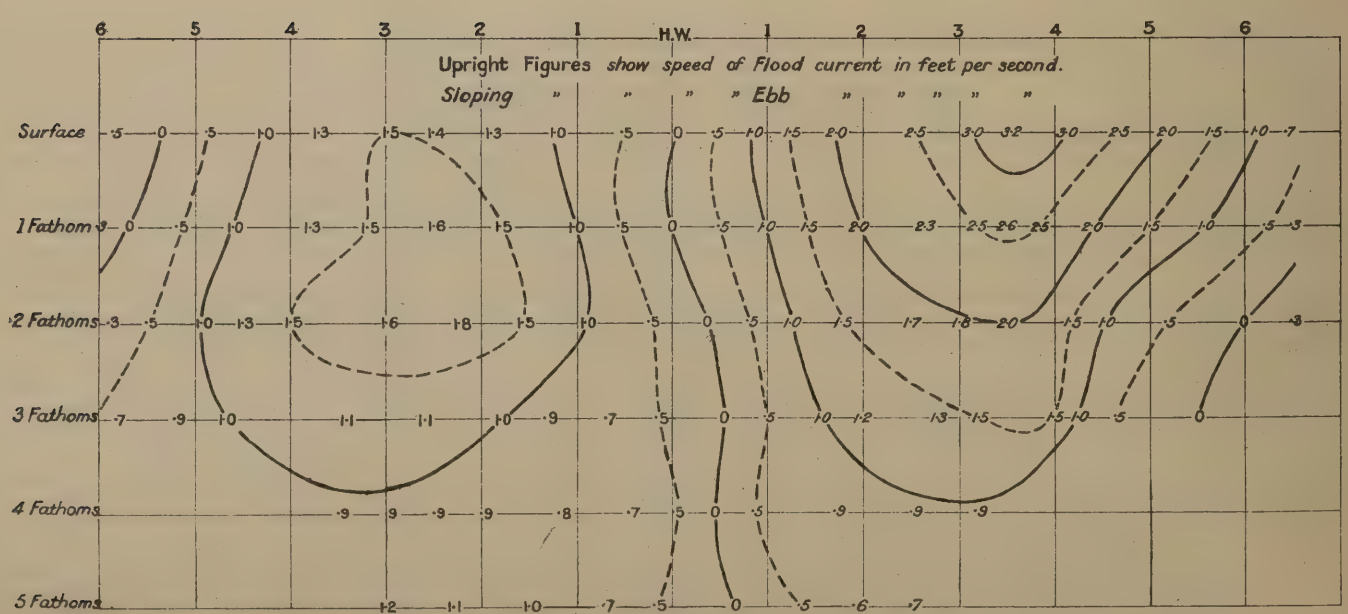
RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT F.III.

Range 11 to 14 feet

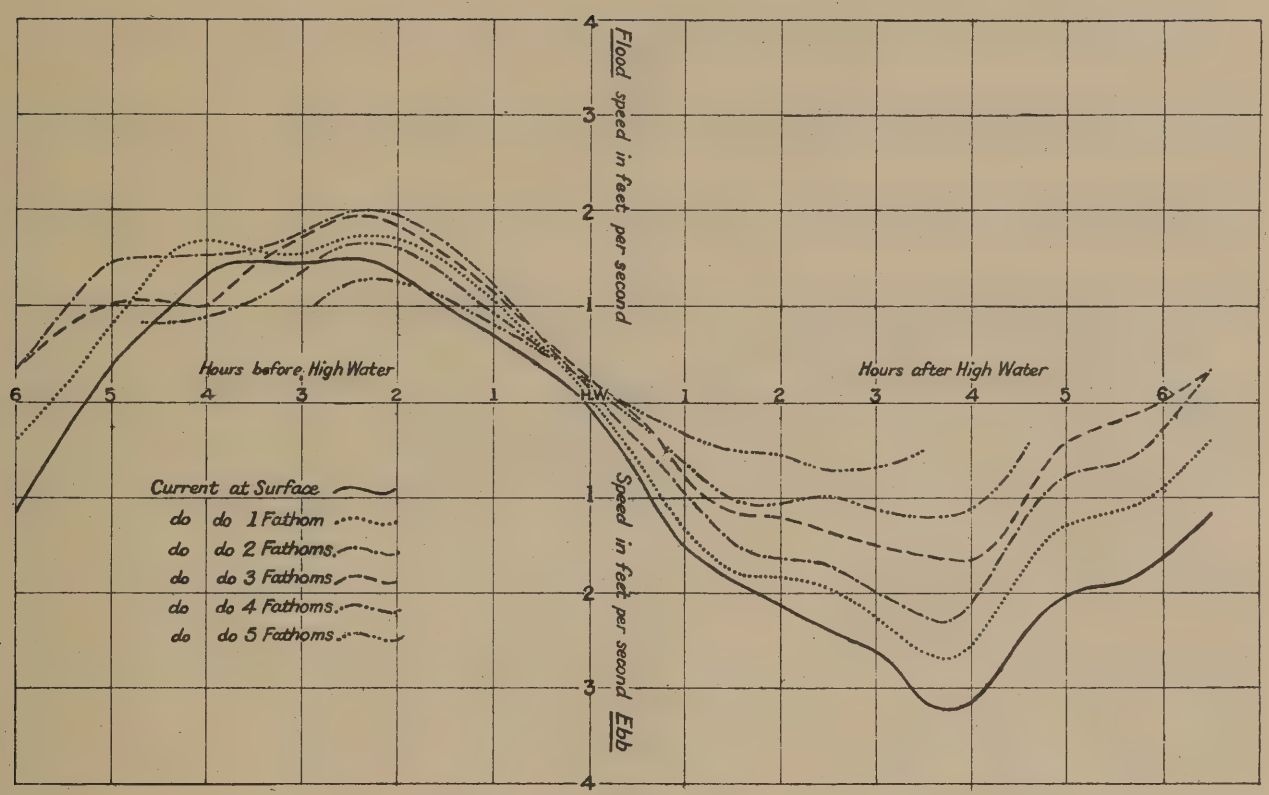


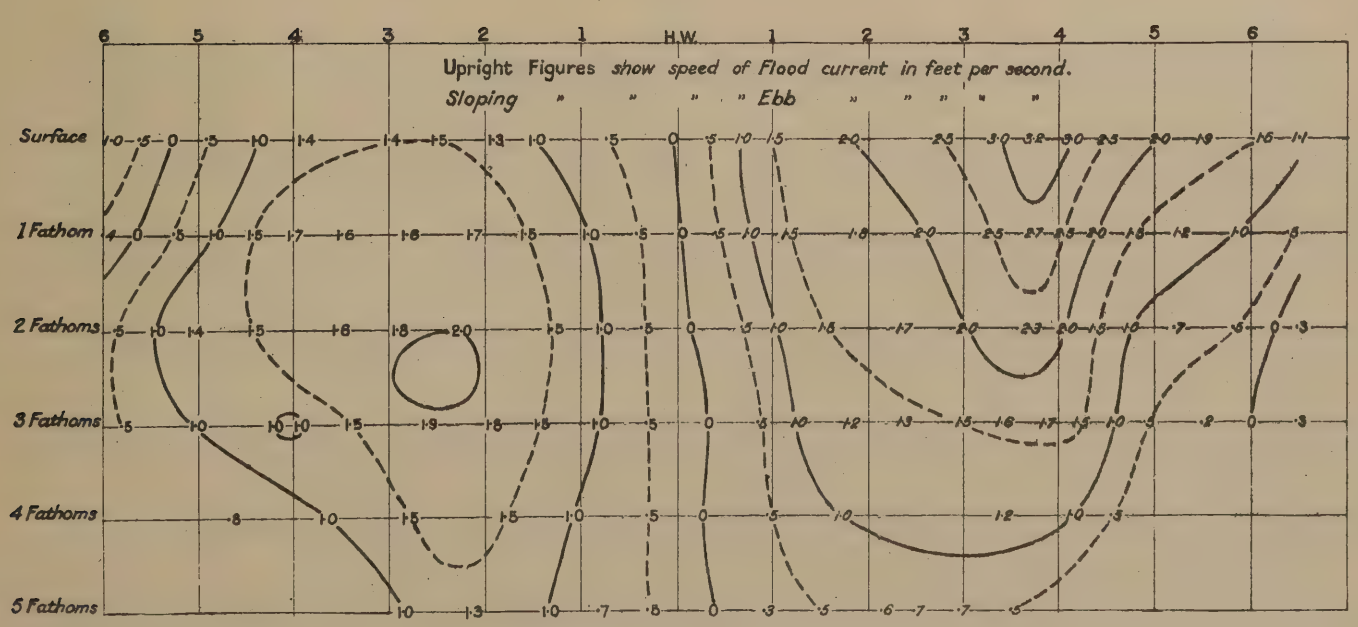


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT F.IV.

Range Above 14 feet

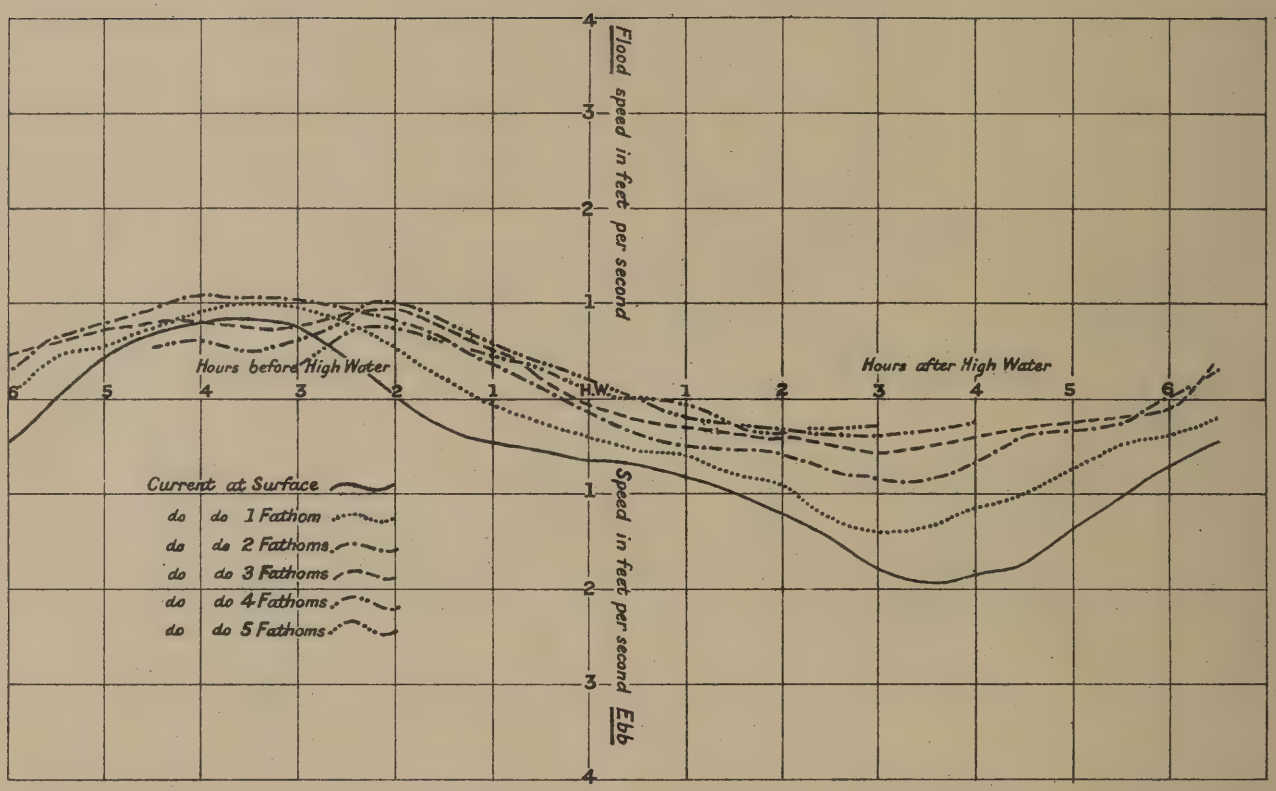


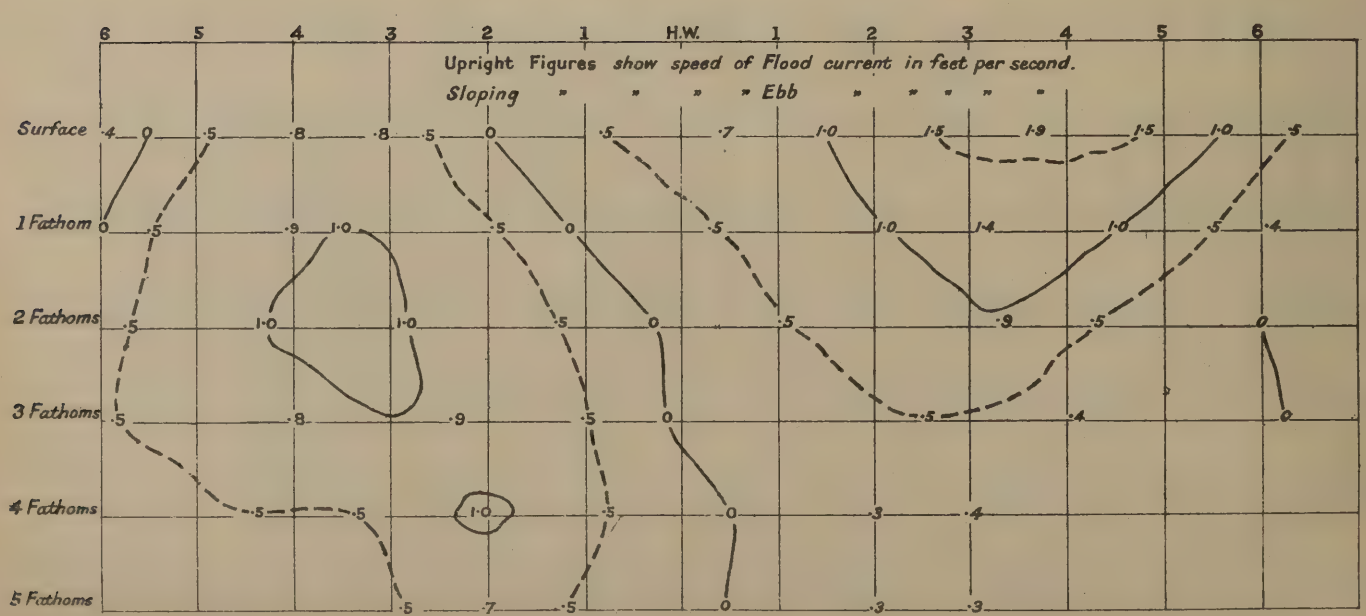


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT G.II.

Range 8 to 11 feet

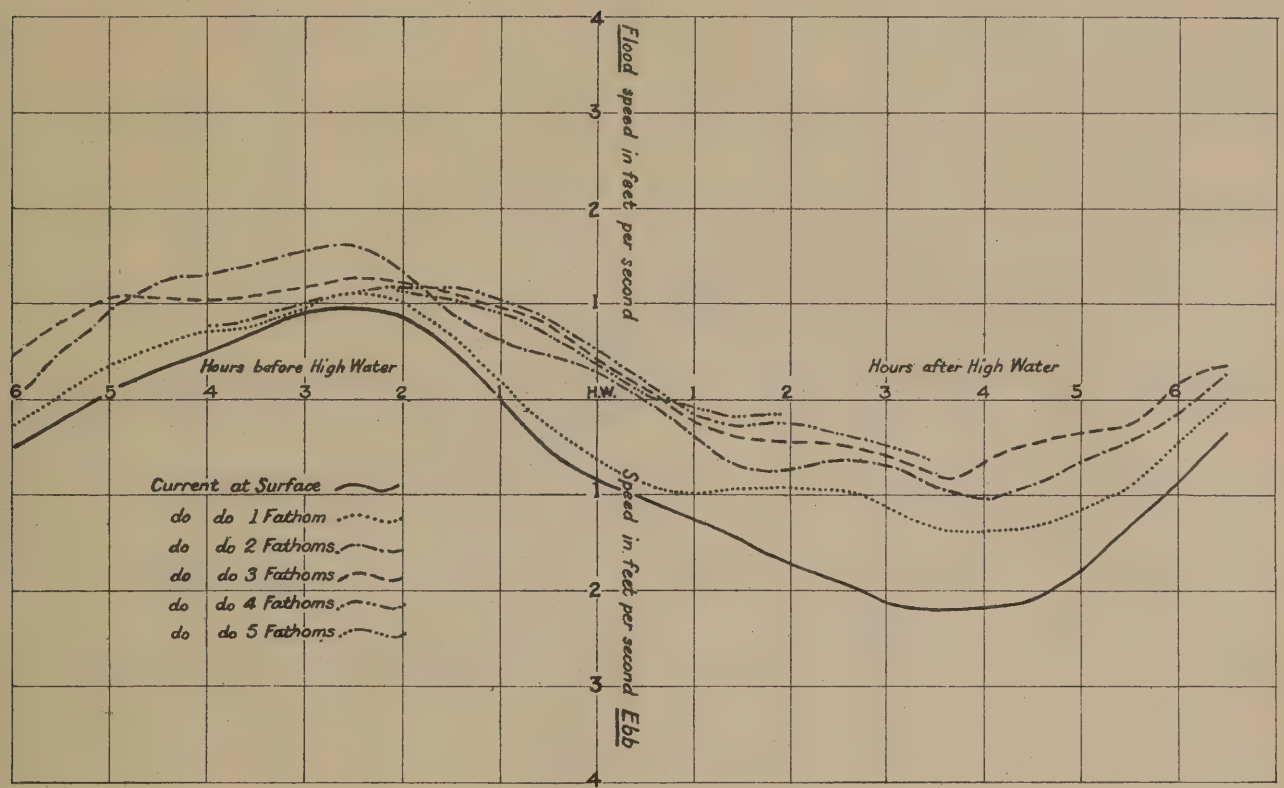


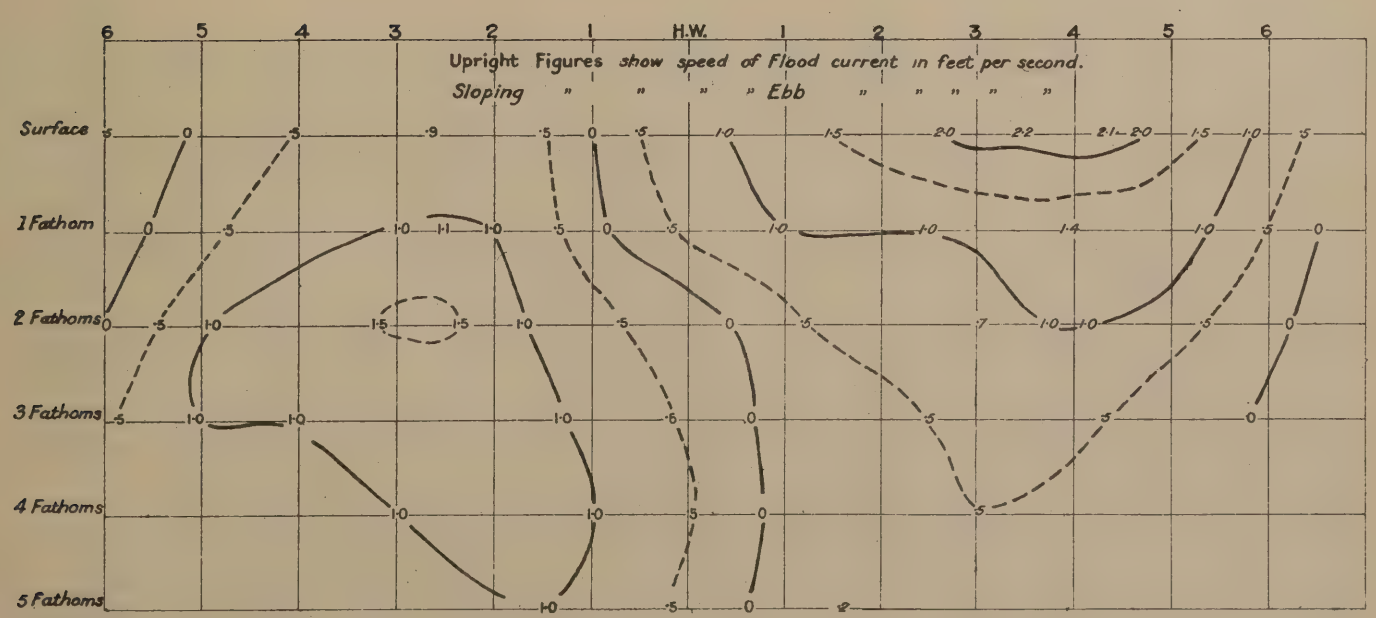


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT G.III.

Range 11 to 14 feet.

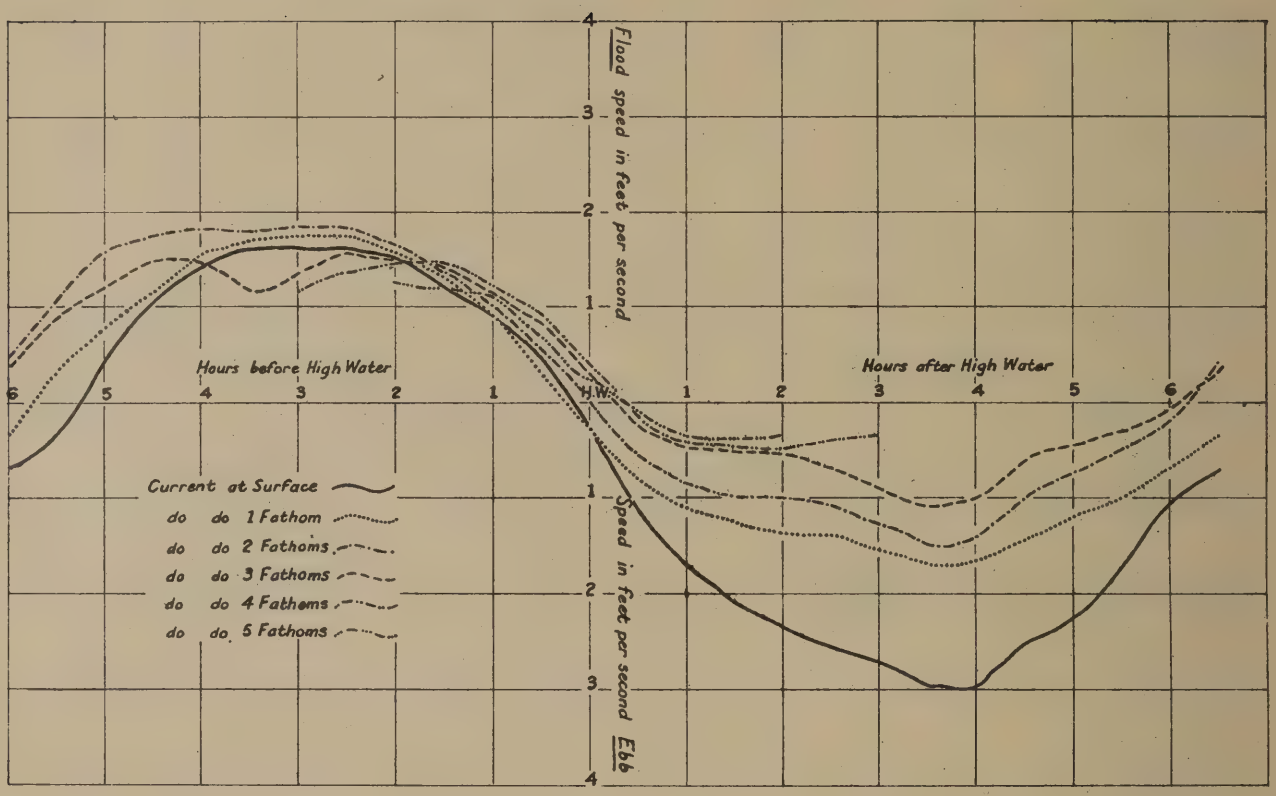


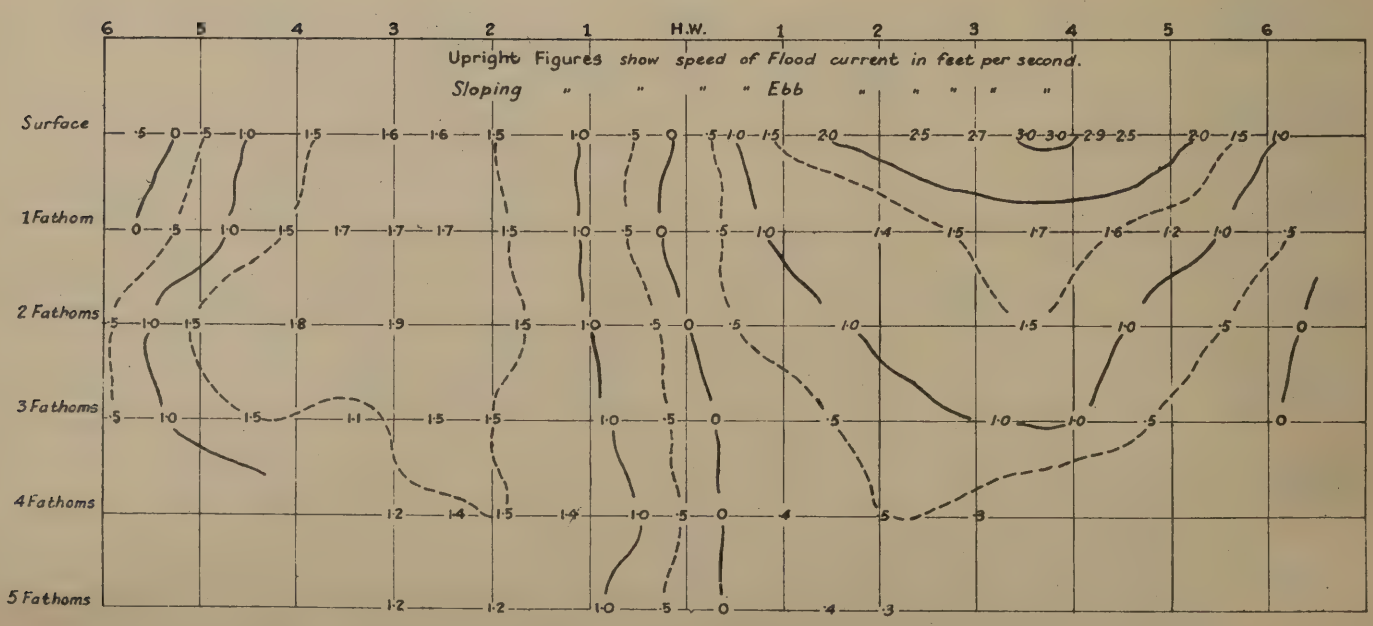


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT G.IV.

Range 14 feet and above

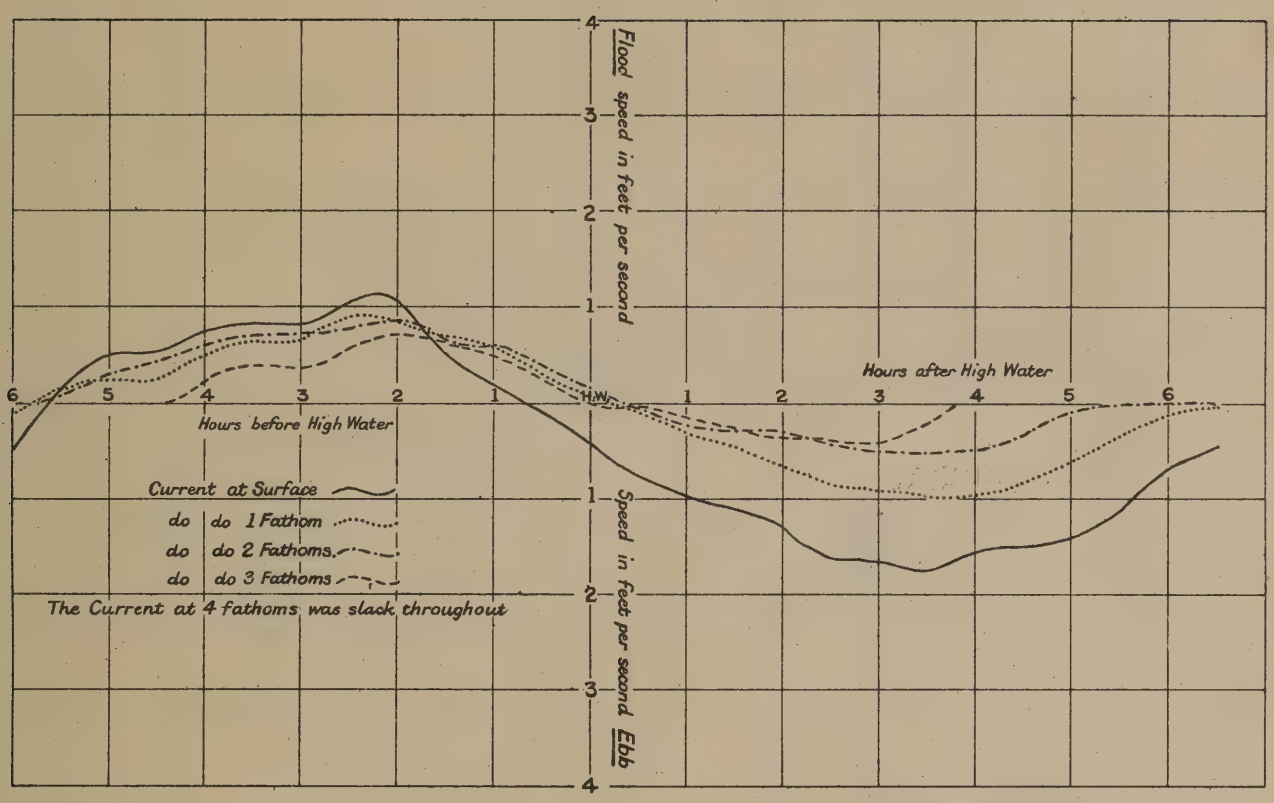


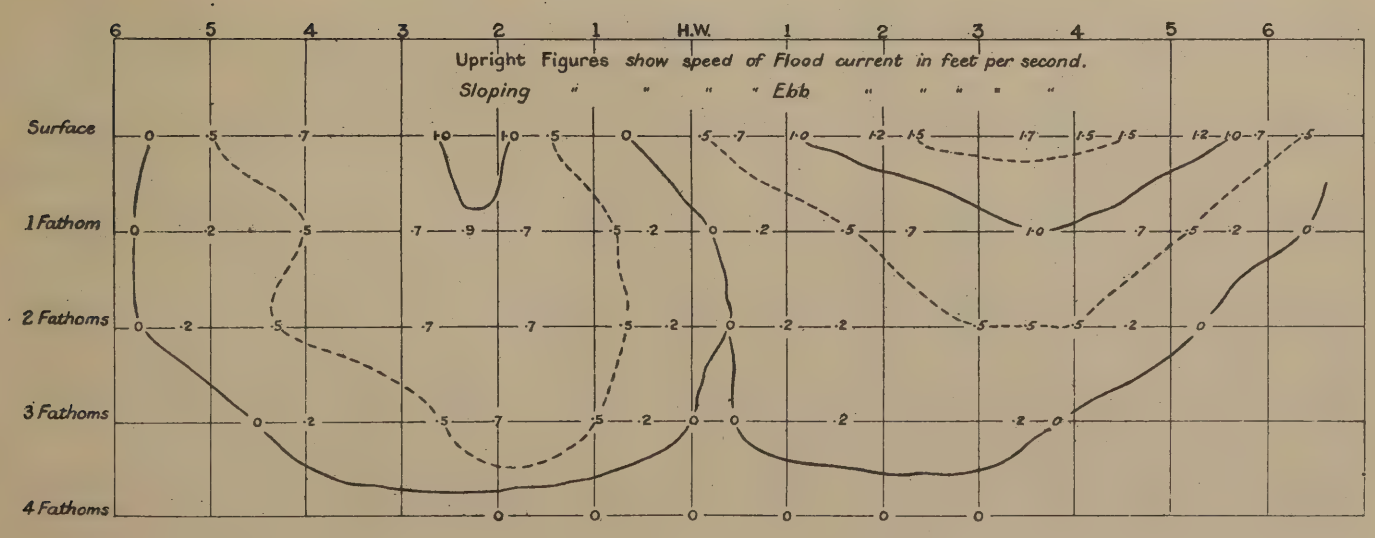


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT H.I.

Range - Below 8 feet

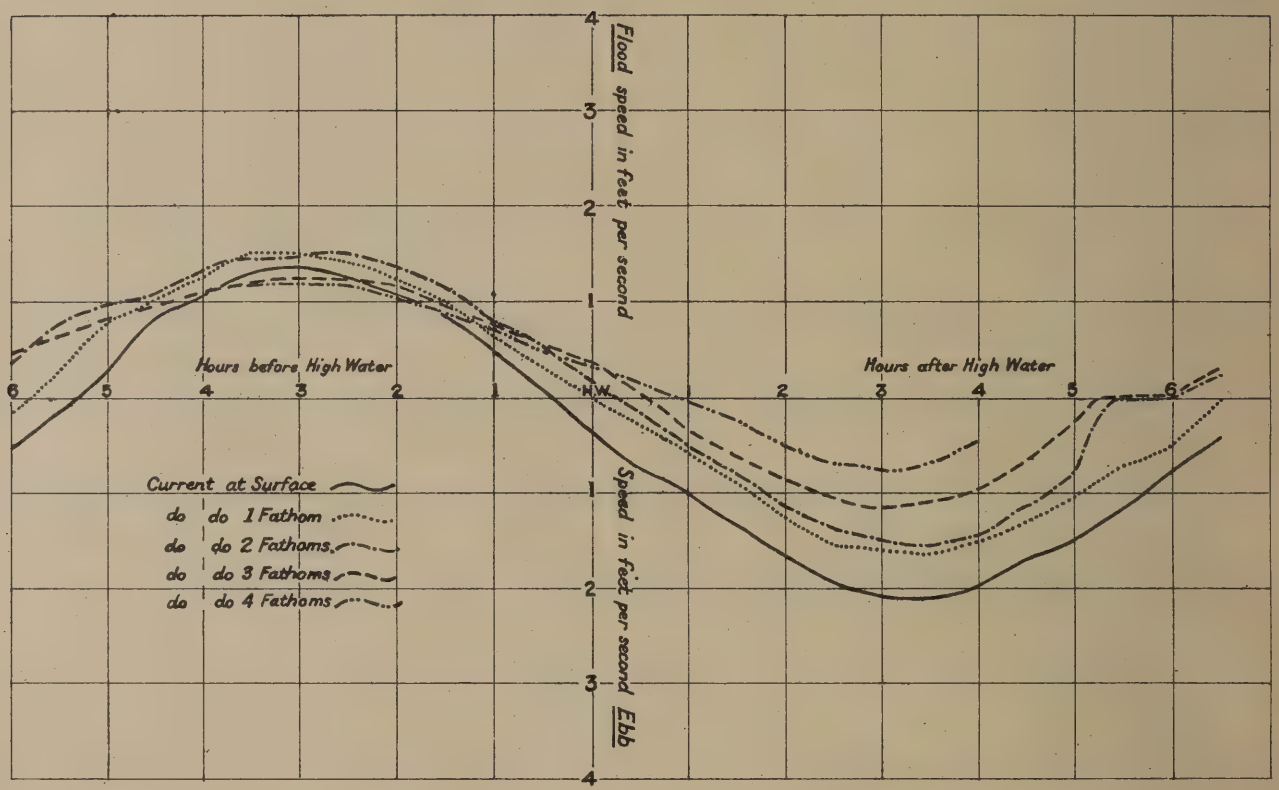


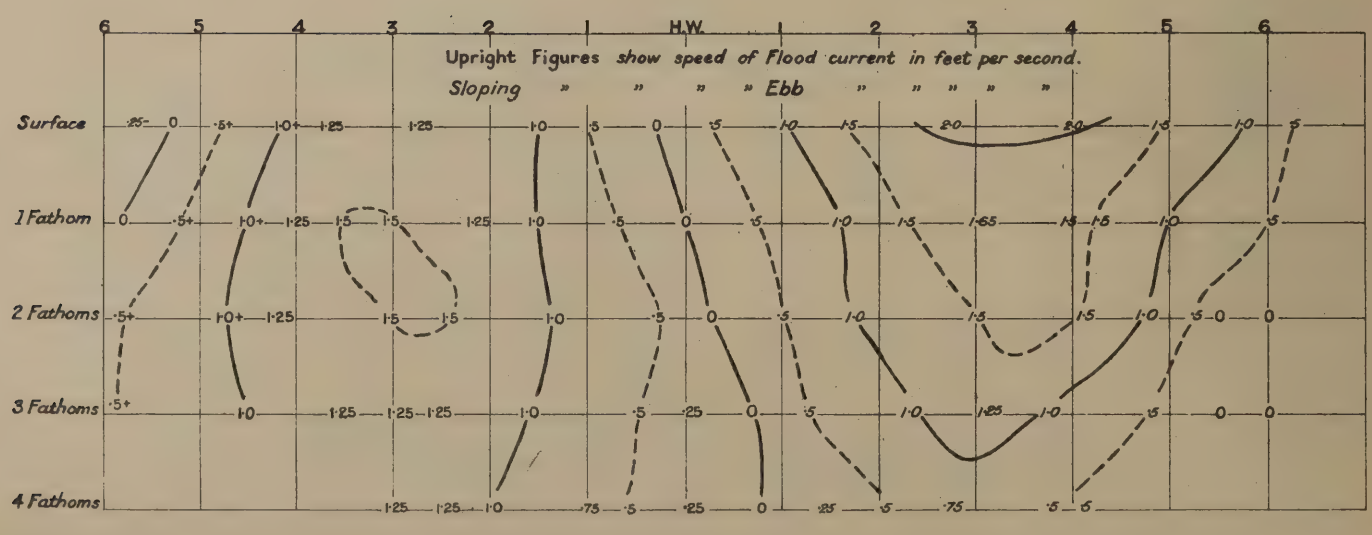


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT H.II.

Range 8 to 11 feet

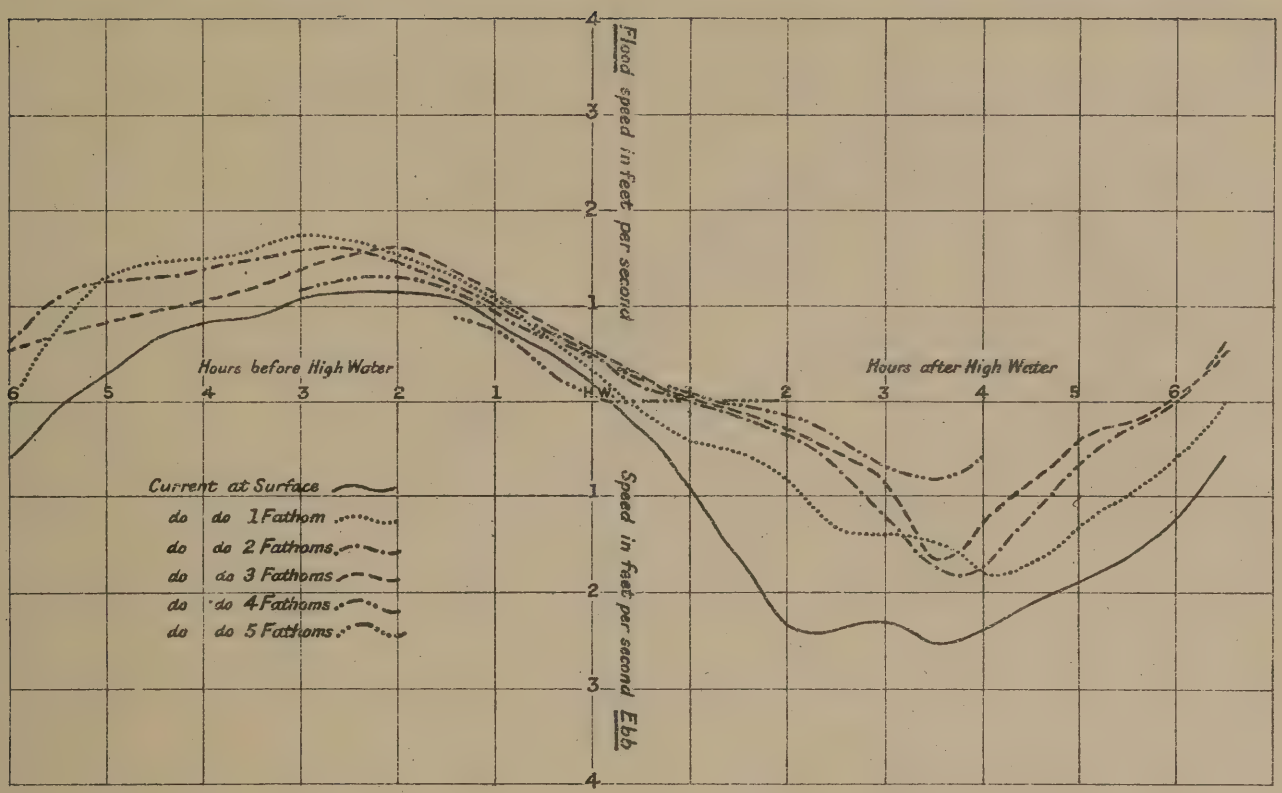


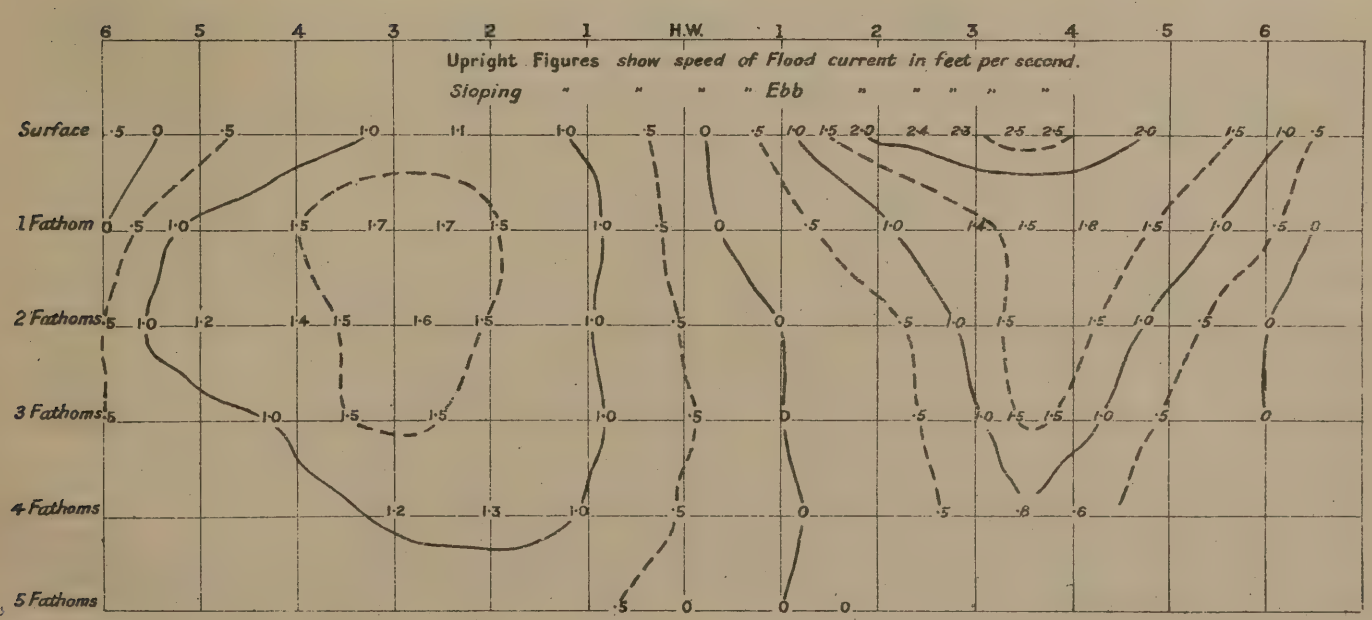


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT H.III.

Range 11 to 14 feet





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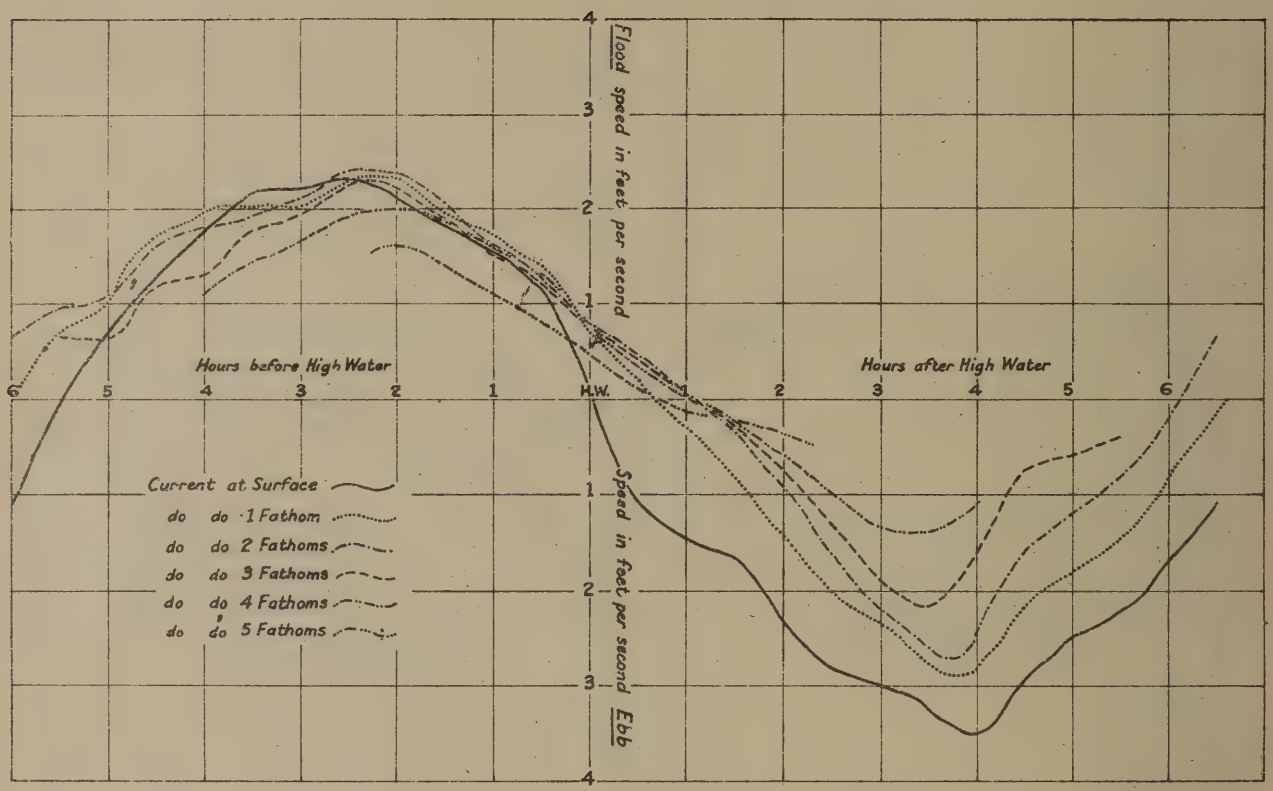
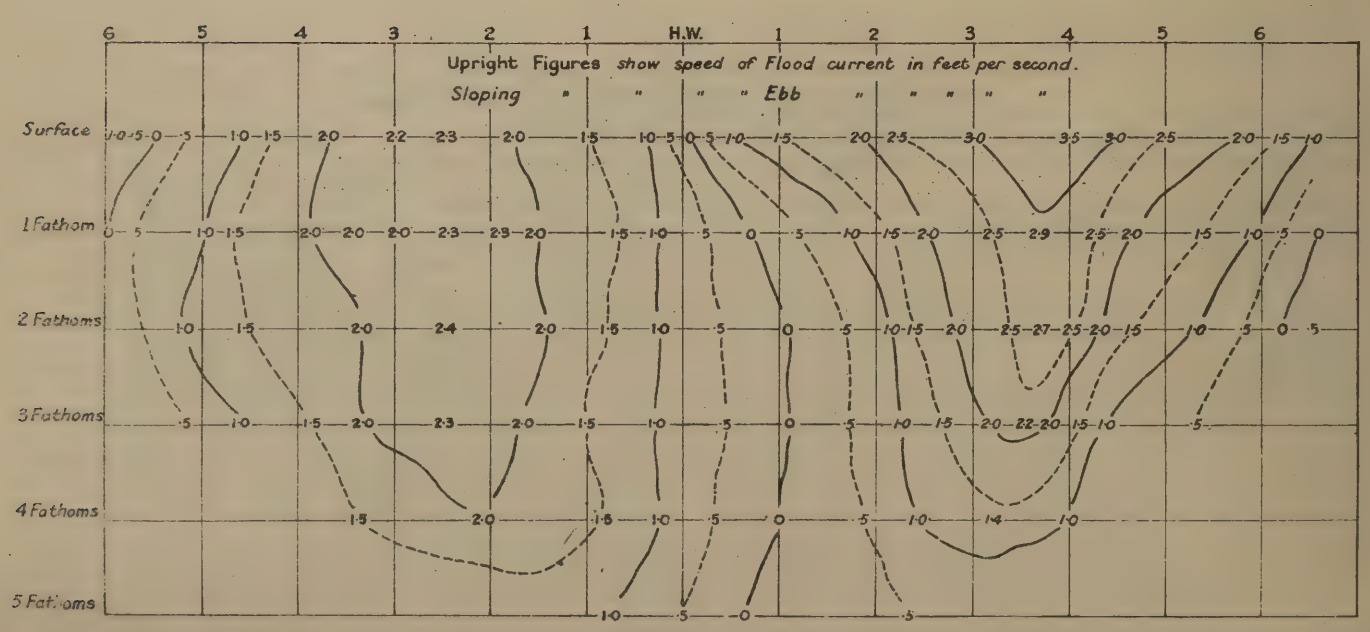
RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT H.IV.

Range above 14 feet





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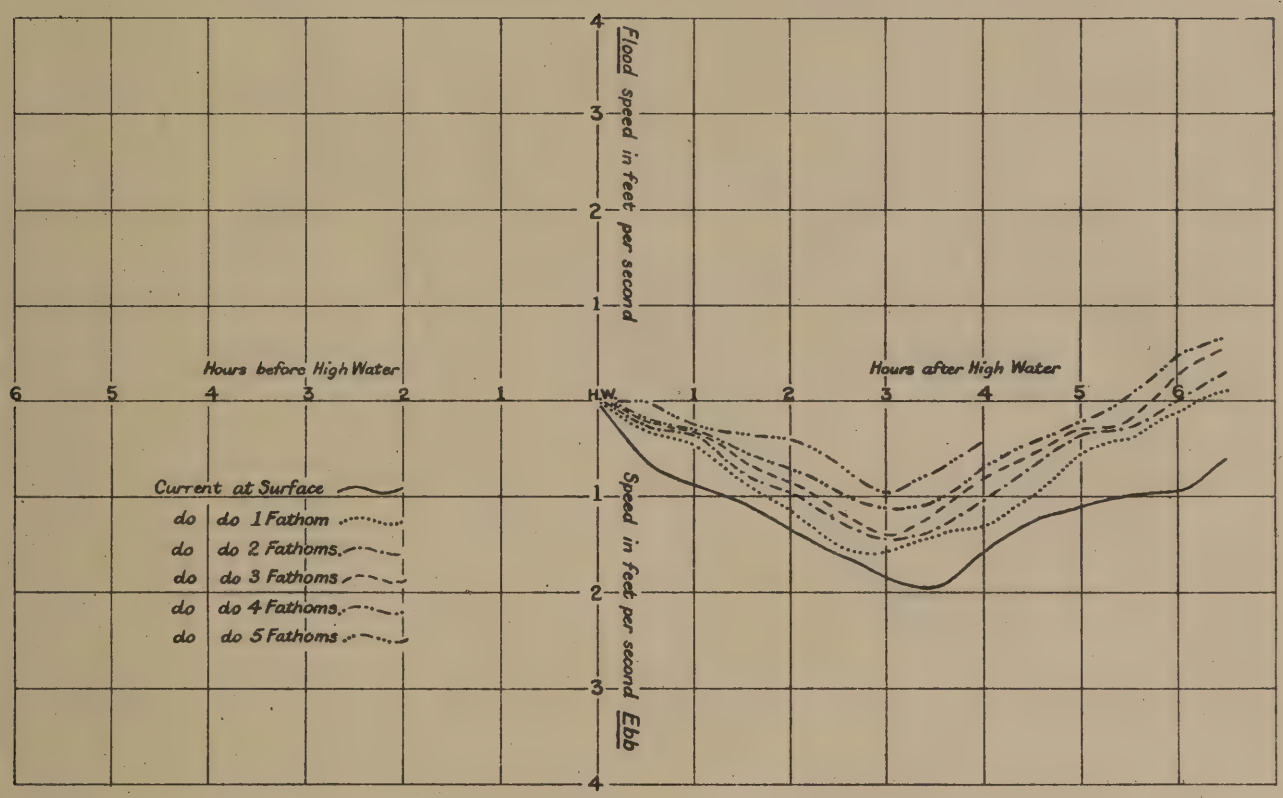
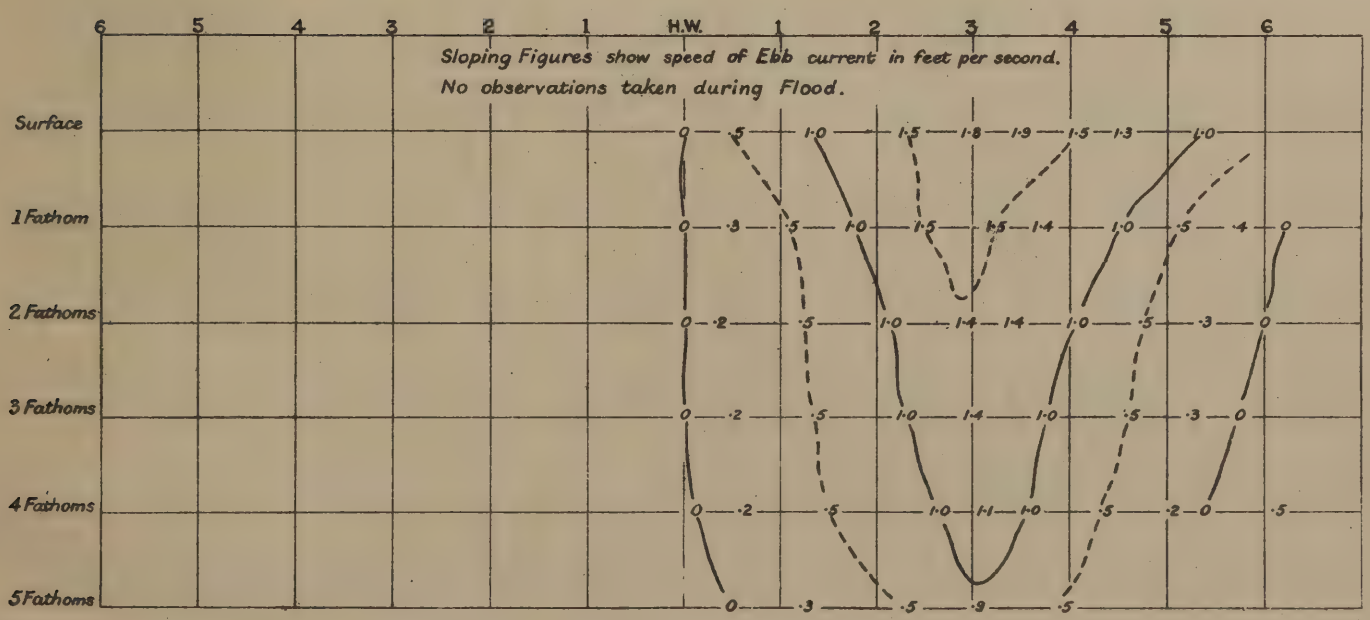
Malby & Sons, Photo-Lith.

RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT I. I.

Range - Below 8 feet

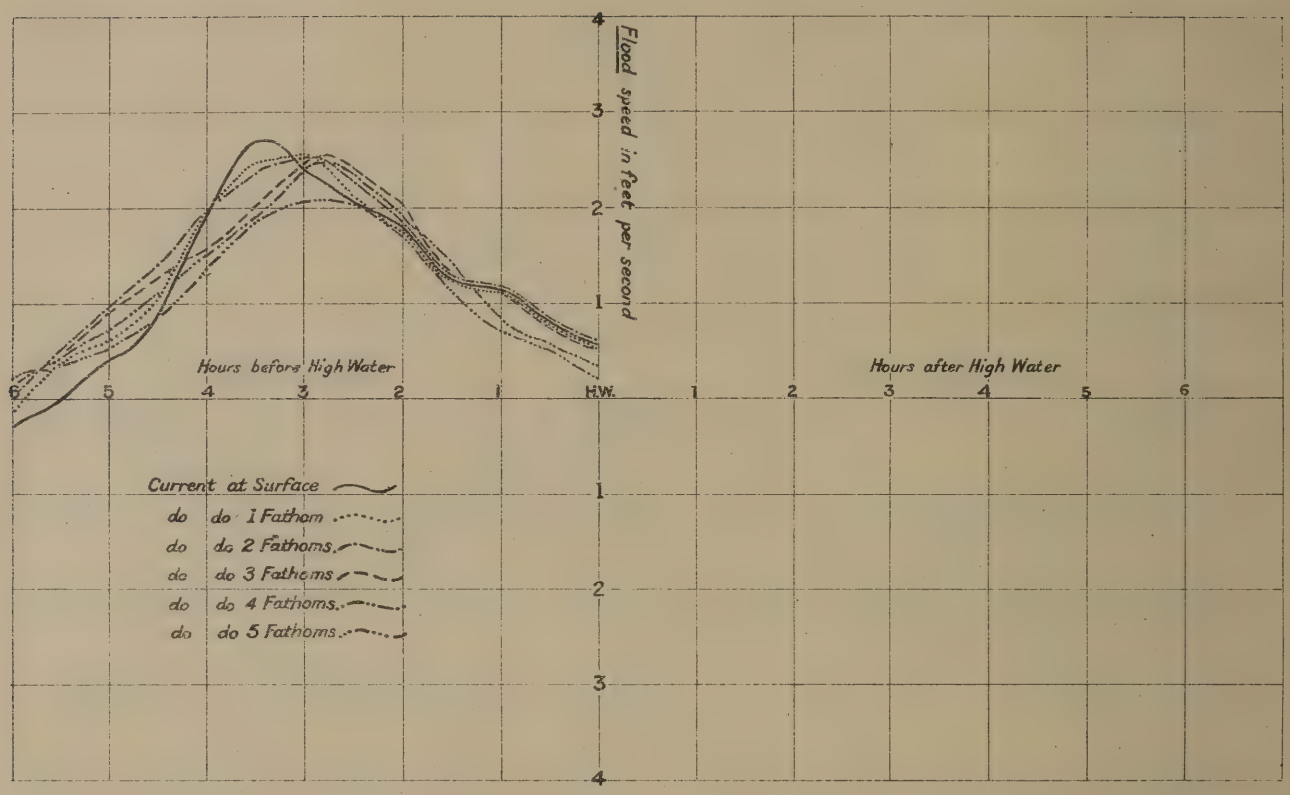


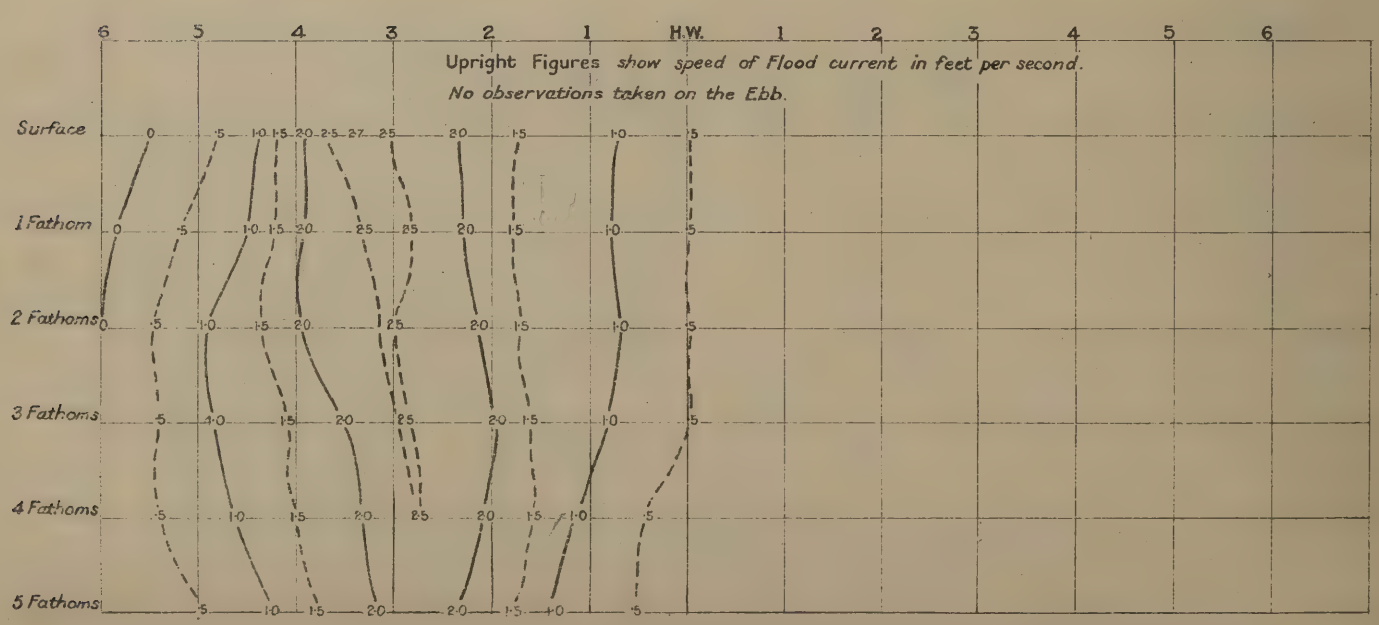


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT I.II.

Range 8 to 11 feet

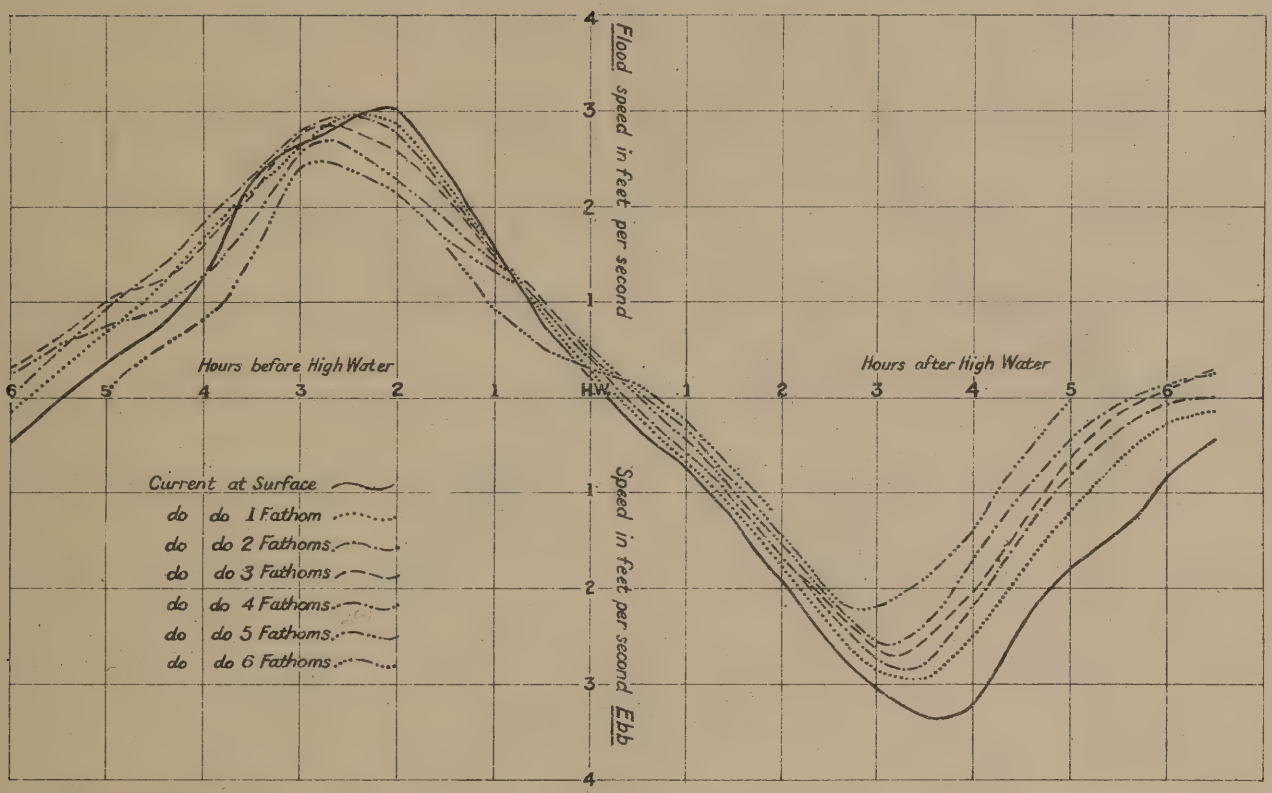


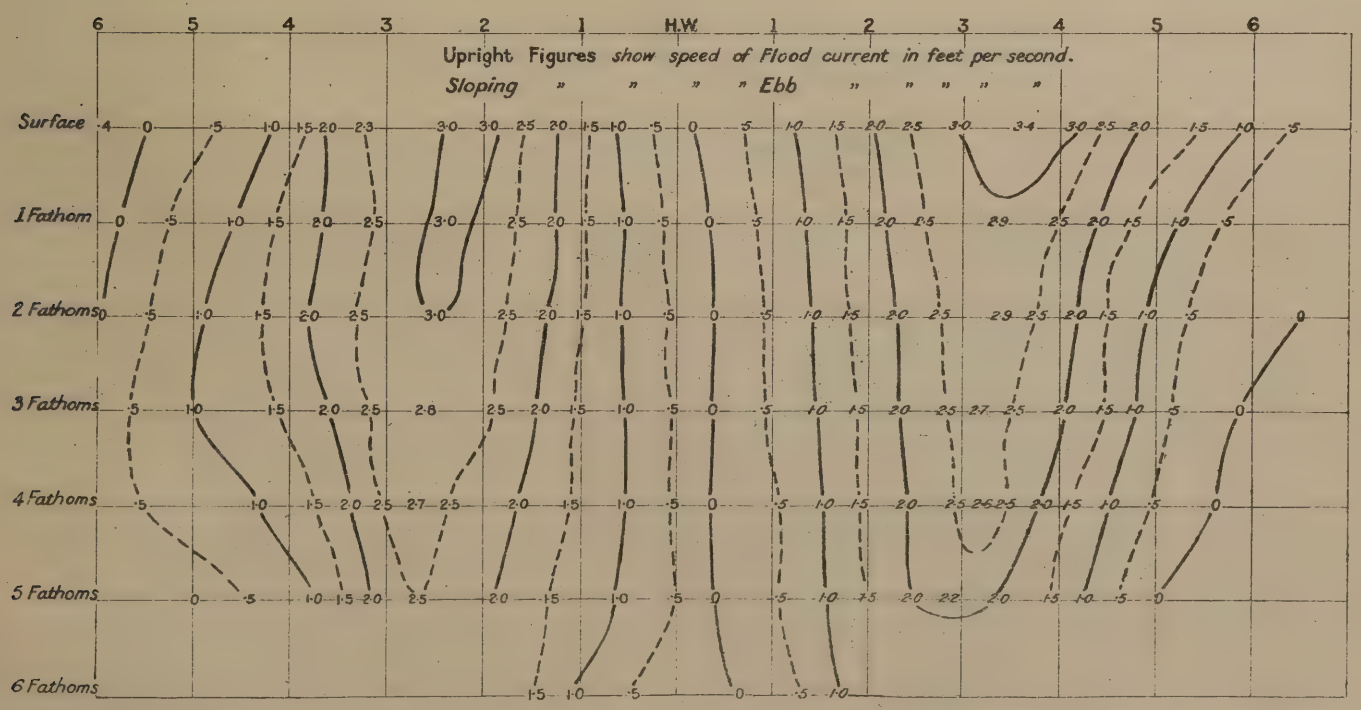


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT I.III.

Range 11 to 14 feet

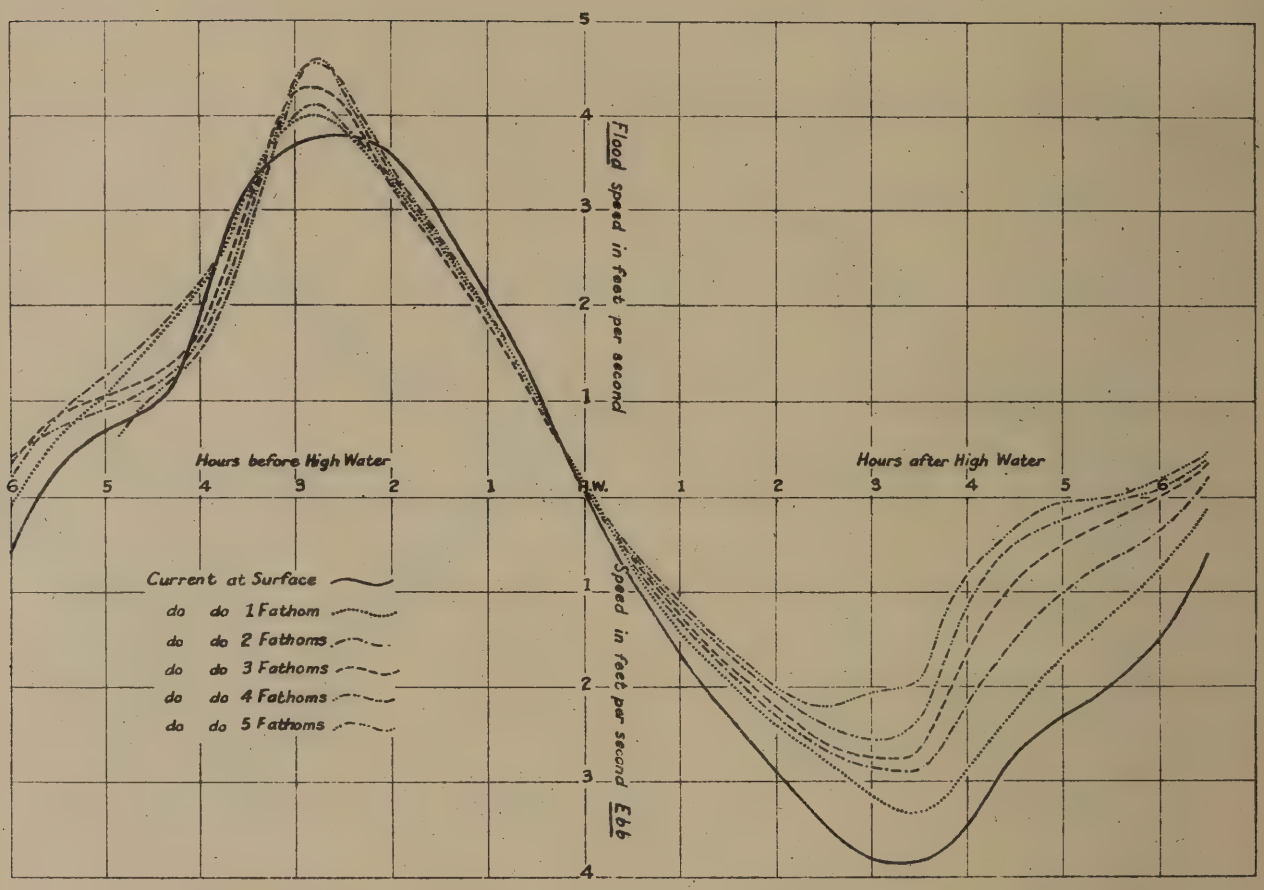


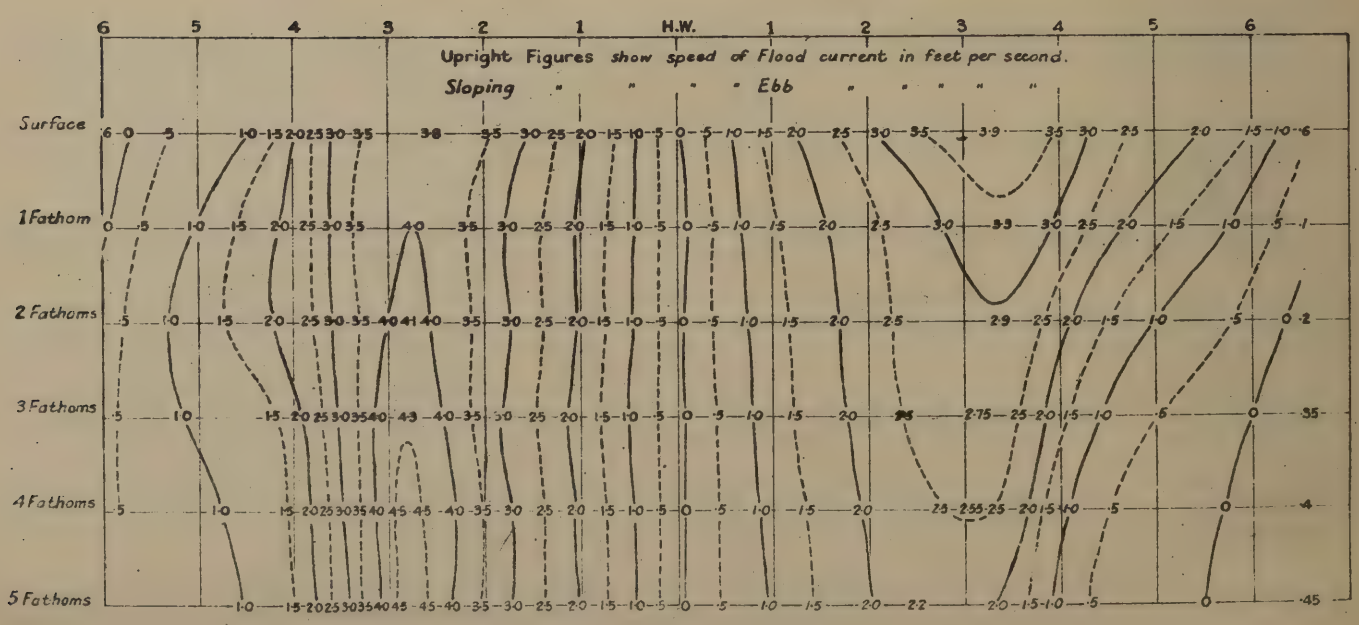


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT I.IV.

Range above 14 feet

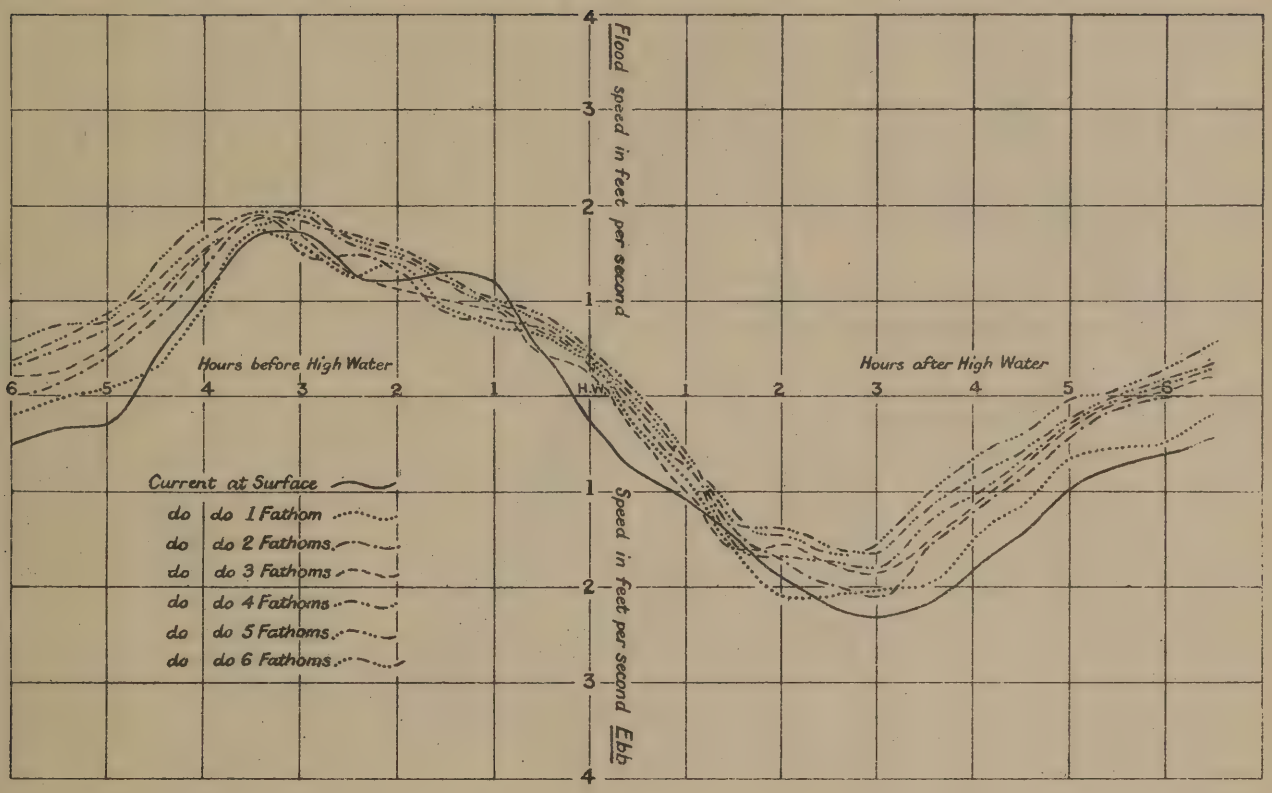


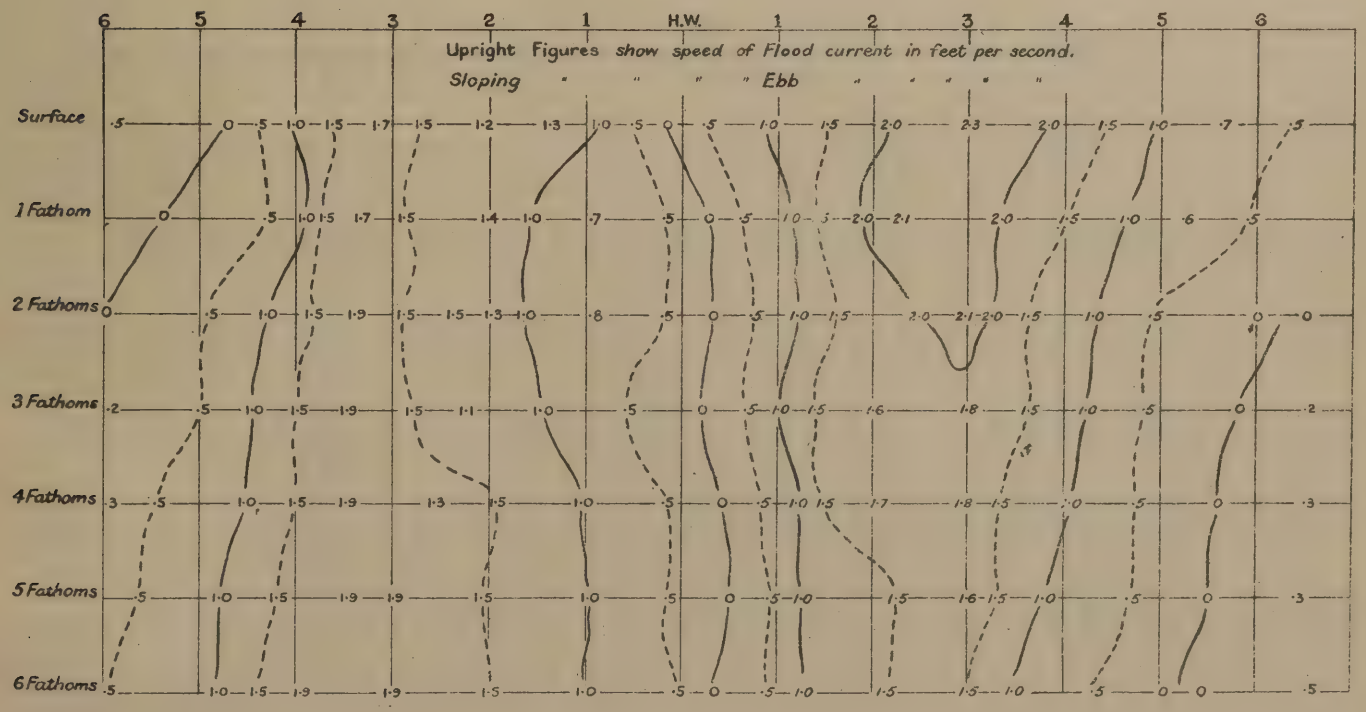


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT K.I

Range - Below 8 feet

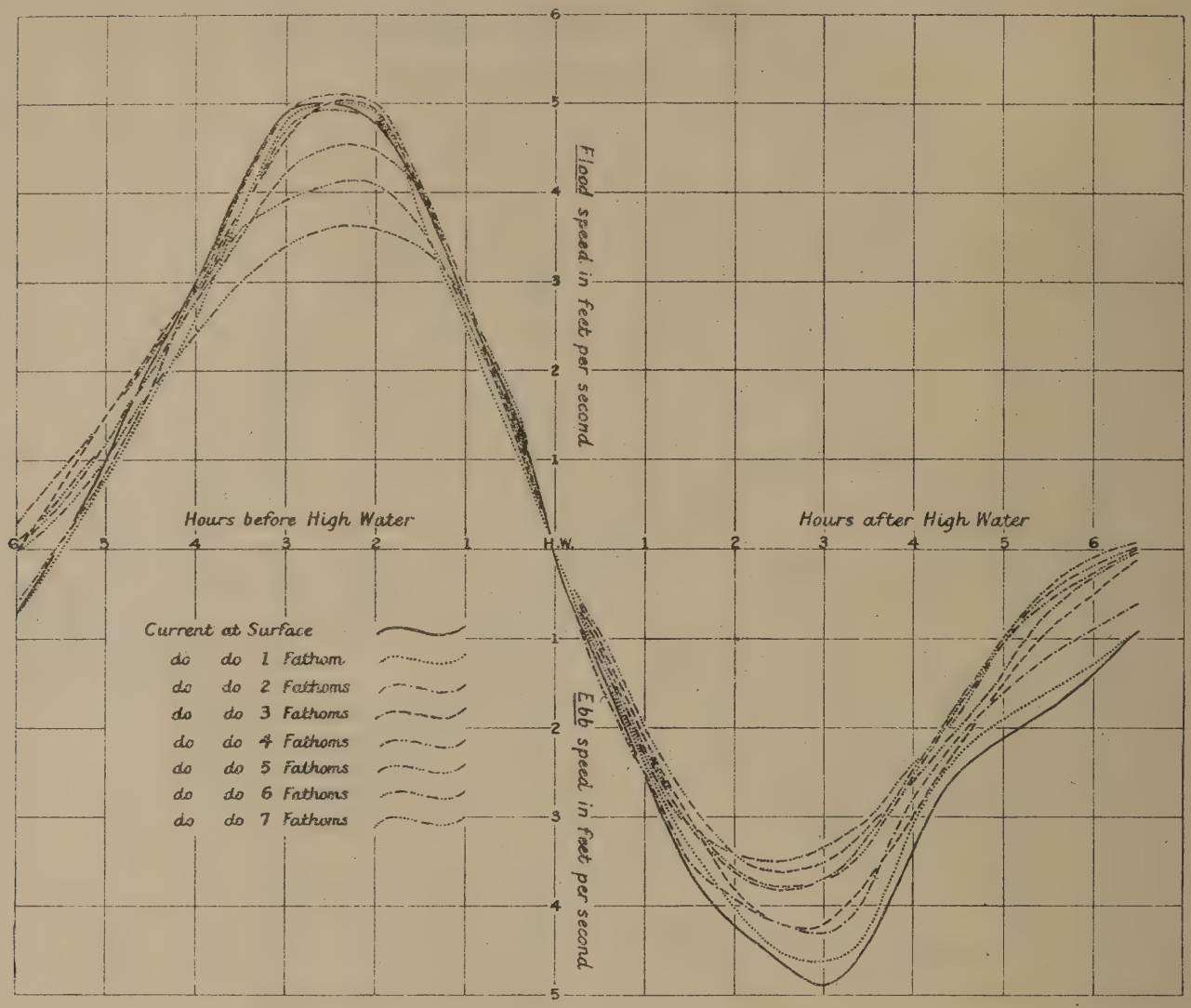


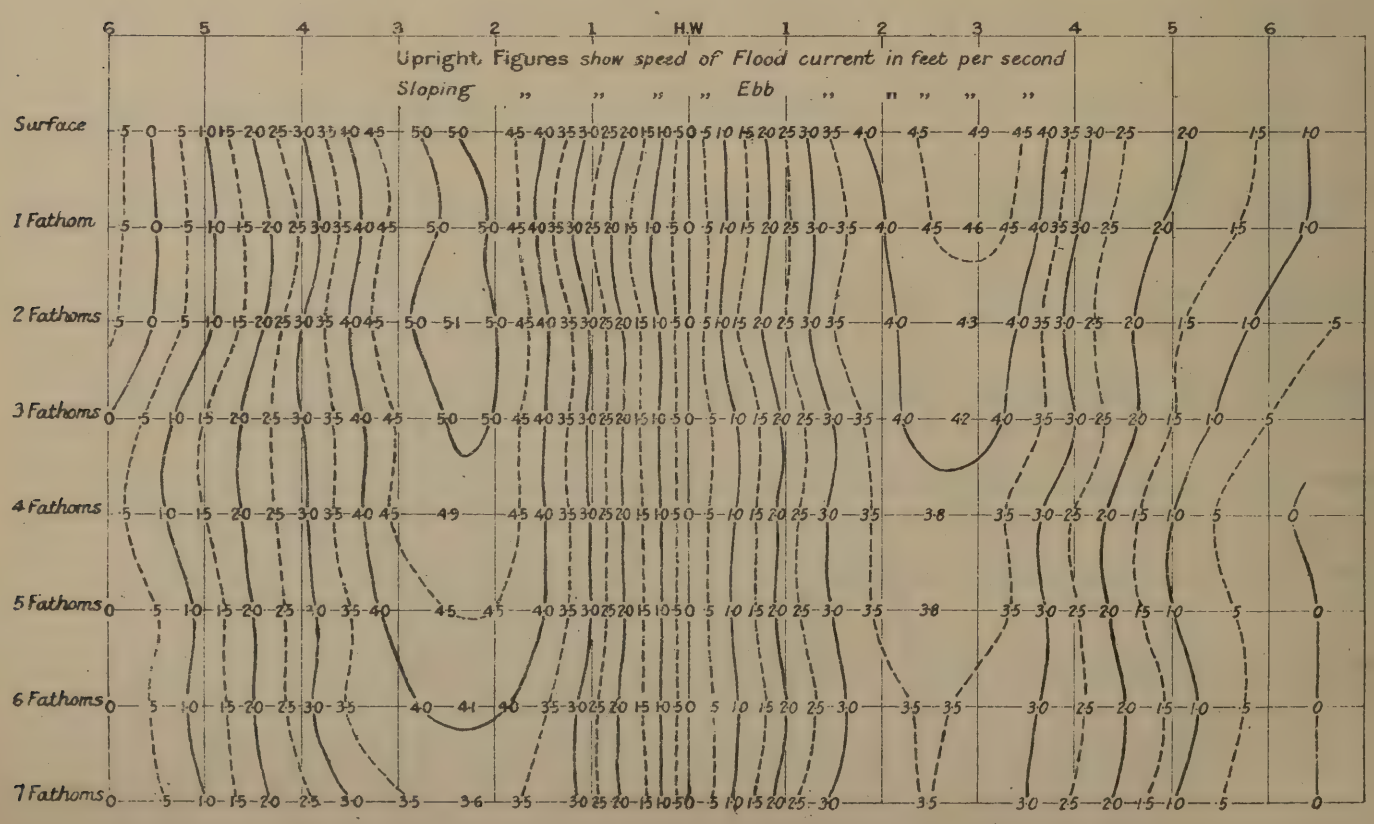


RIVER TEES SURVEY 1929

TIDAL OBSERVATIONS AT K.IV

Range above 14 feet



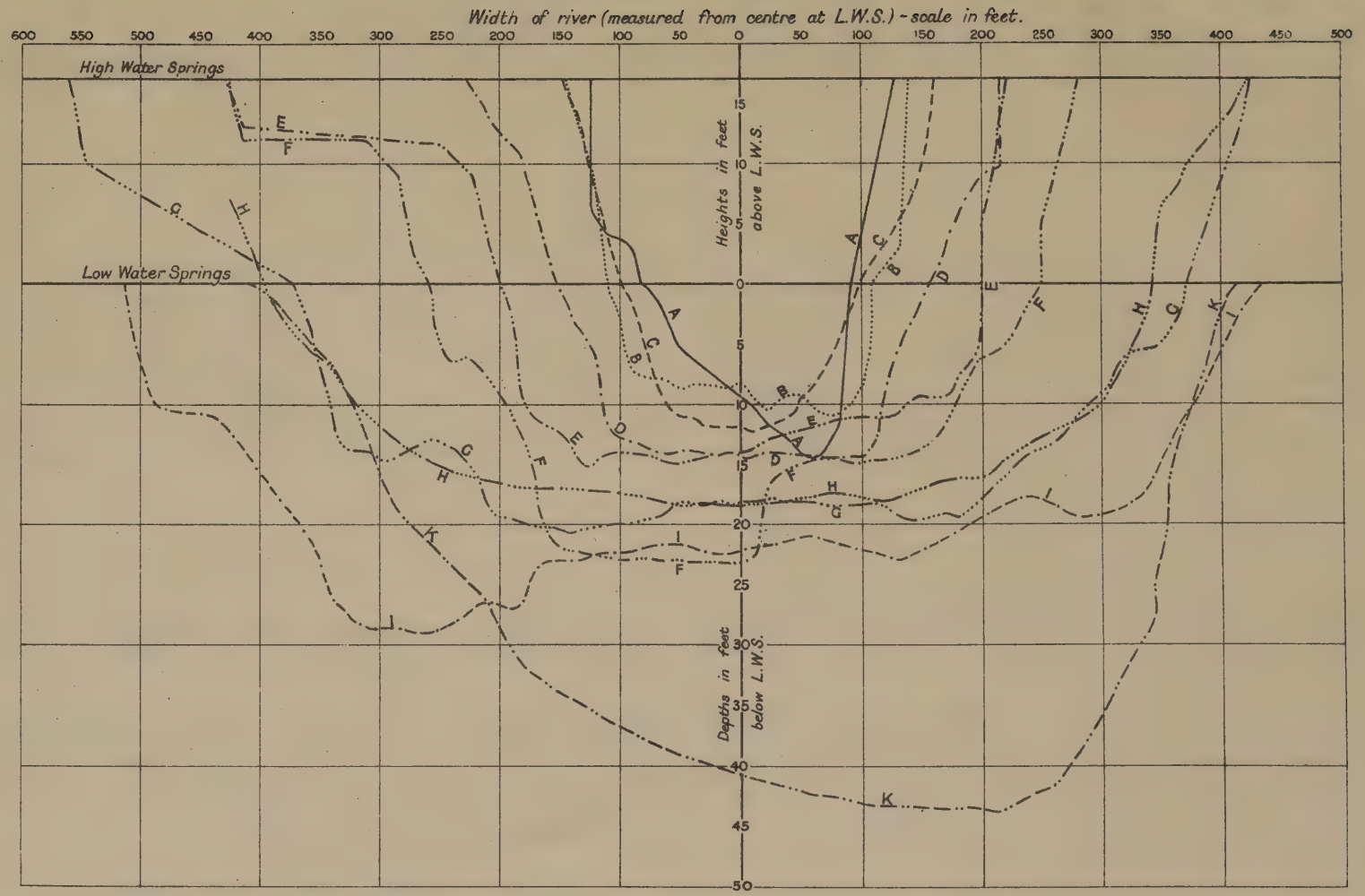


RIVER TEES SURVEY 1929

AREAS of CROSS SECTION from T.C.C. SOUNDINGS.

Depth scale magnified 10 times.
Mean Tide Level (M.T.L.) 8·40ft. above zero (L.W.S.)
High Water Springs (H.W.S.) 17·0ft above zero.

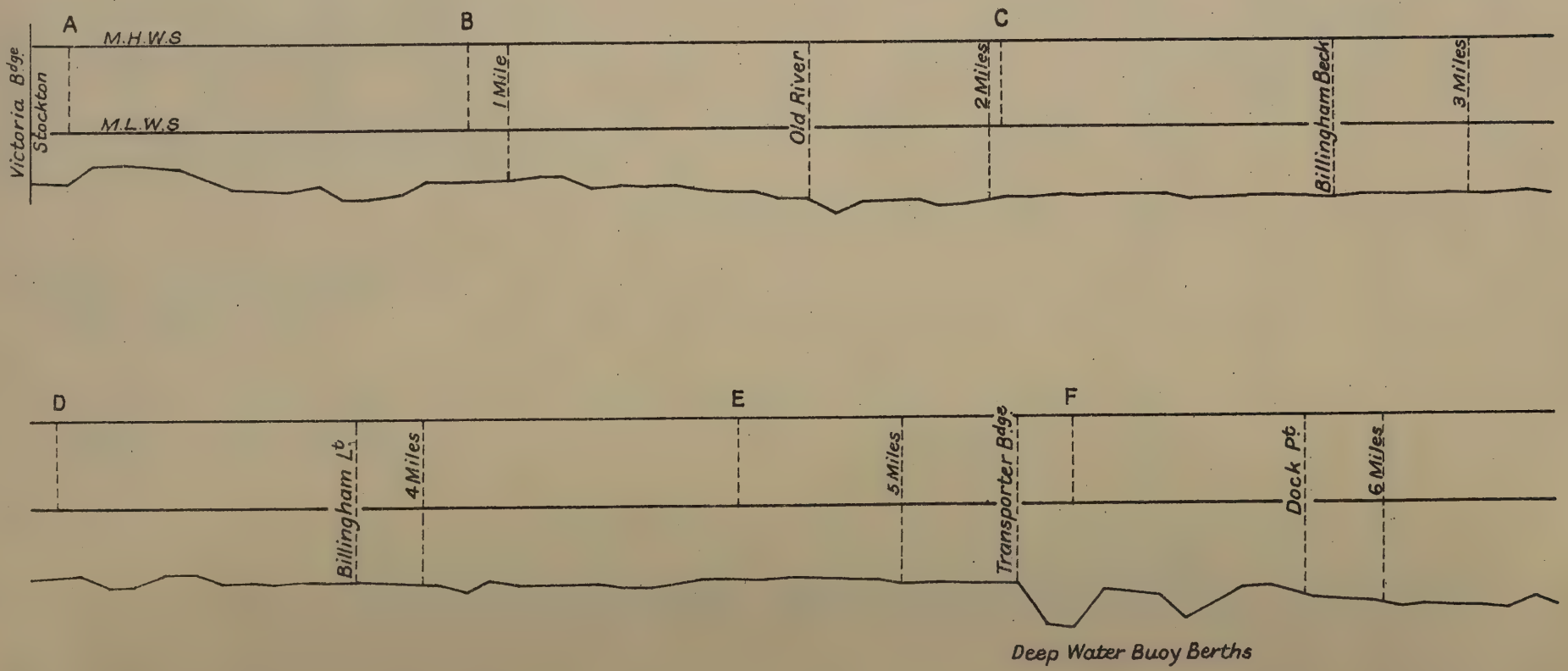
	Areas of cross section in sq. feet		
	at L.W.S.	at M.T.L.	at H.W.S.
Station A	1525	3280	5355
" B	1860	3965	6260
" C	1750	3725	6170
" D	3515	6405	9925
" E	4720	8230	12930
" F	7660	12135	17565
" G	11470	18540	26720
" H	10640	17140	
" I	18375		
" K	24860		

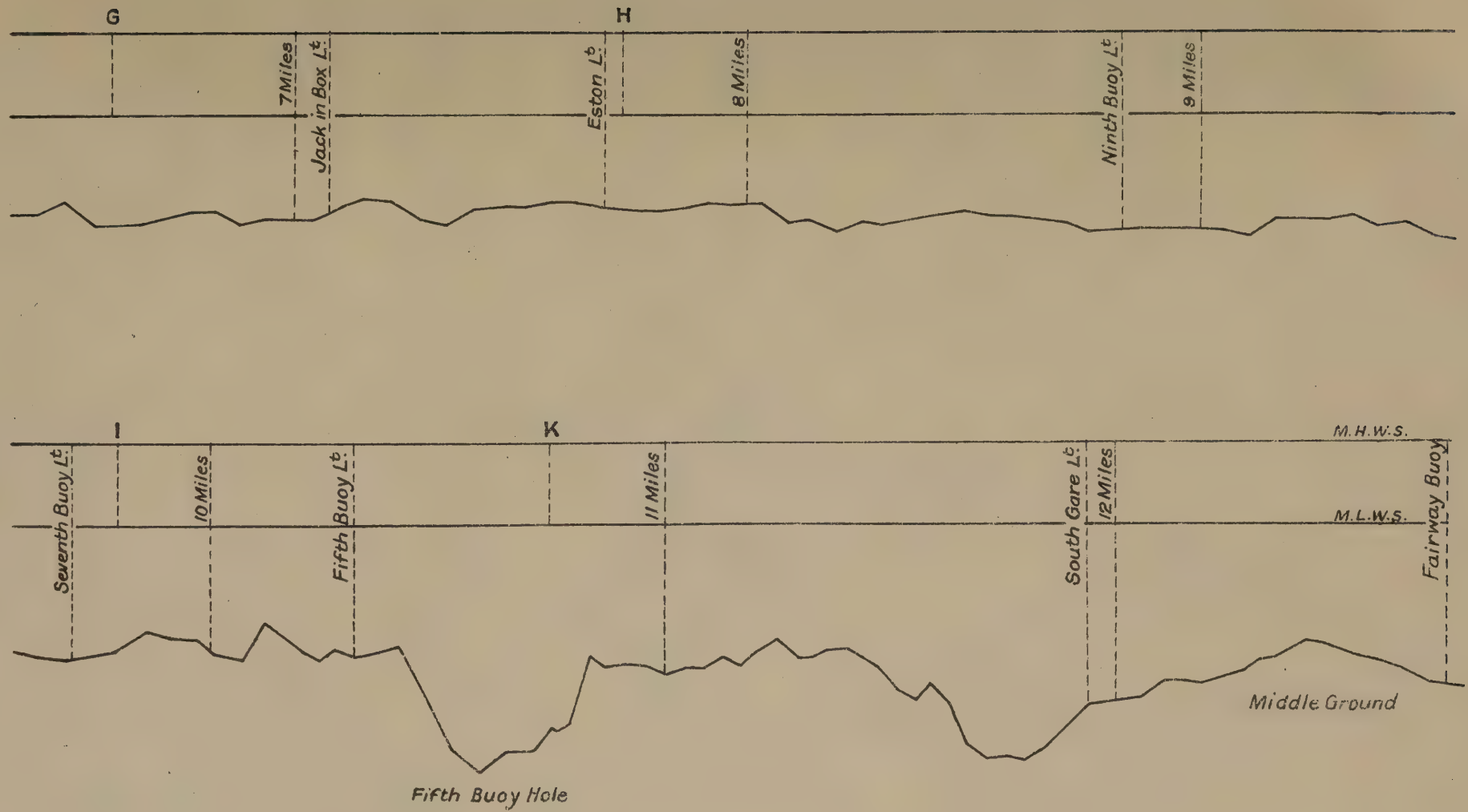


RIVER TEES SURVEY 1929

Longitudinal Section along centre line of River Tees between Victoria Bridge, Stockton and Fairway Buoy from T.C.C. soundings

Observing Stations lettered A to K





Longitudinal Scale

Ft 1000 0 5000 10,000 Ft 2 Miles

Vertical Scale

Feet 10 0 70 Feet

RIVER TEES SURVEY 1929

Estimated movement of water moving in Surface to 1 Fathom layer, commencing at station B at High Water.

Distance from B to River mouth = 51,000ft

Flood run marked thus ——

Ebb " " " - - - -

Upright Figures show Flood current

Sloping " " Ebb "

Times of passing each station shown in hours before or after H.W.

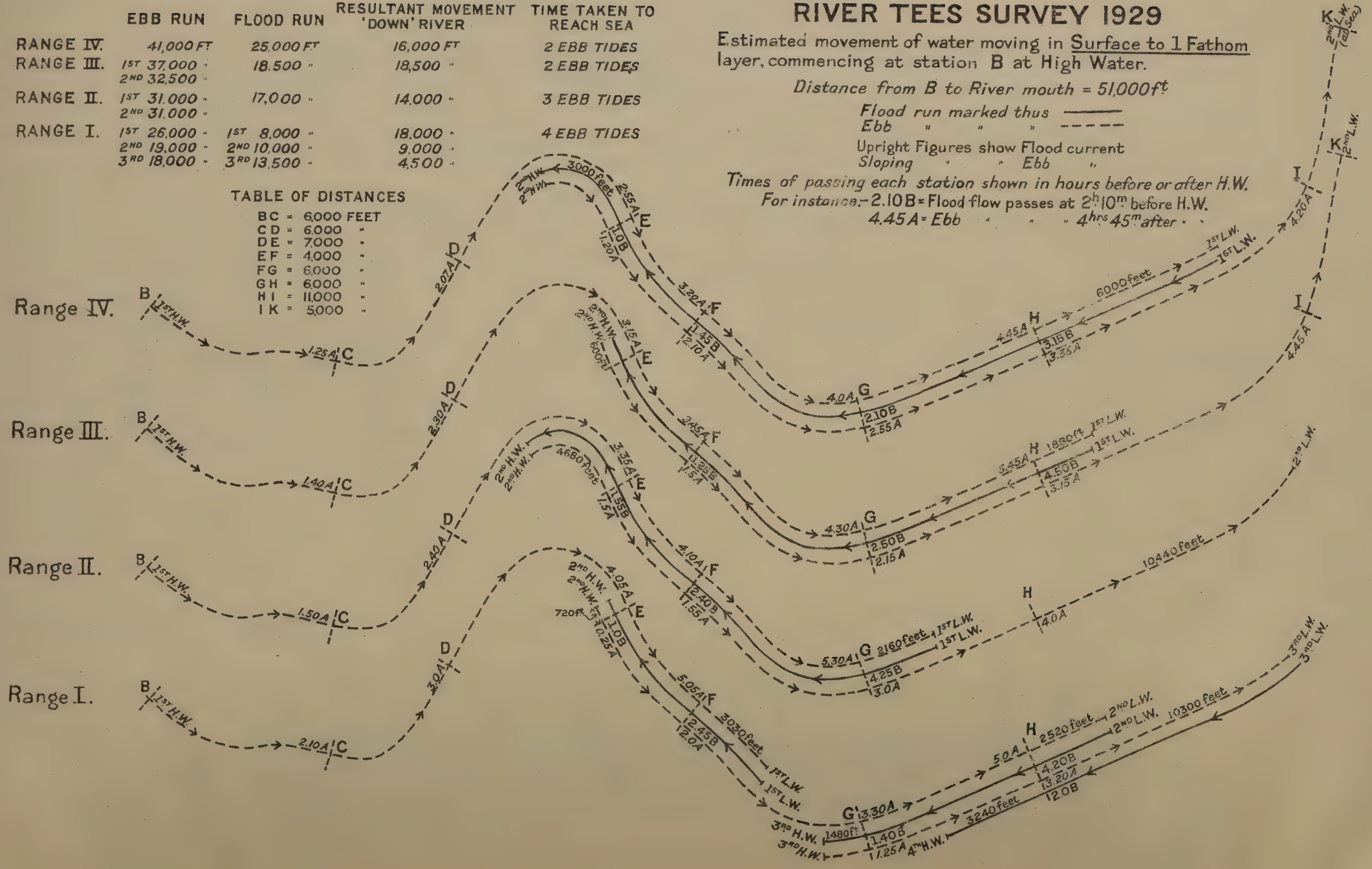
For instance:- 2.10B = Flood flow passes at $2^h 10^m$ before H.W.

4.45A = Ebb " " $4^{hrs}\ 45^m$ after "

	EBB RUN	FLOOD RUN	RESULTANT MOVEMENT 'DOWN' RIVER	TIME TAKEN TO REACH SEA
RANGE IV.	41,000 FT	25,000 FT	16,000 FT	2 EBB TIDES
RANGE III.	1ST 37,000 " 2ND 32,500 "	18,500 "	18,500 "	2 EBB TIDES
RANGE II.	1ST 31,000 " 2ND 31,000 "	17,000 "	14,000 "	3 EBB TIDES
RANGE I.	1ST 26,000 " 2ND 19,000 " 3RD 18,000 "	1ST 8,000 " 2ND 10,000 " 3RD 13,500 "	18,000 " 9,000 " 4,500 "	4 EBB TIDES

TABLE OF DISTANCES

BC	6,000 FEET
CD	6,000 "
DE	7,000 "
EF	4,000 "
FG	6,000 "
GH	11,000 "
IK	5,000 "



RIVER TEES SURVEY 1929

Estimated movement of water moving in Surface to 2 Fathom layer, commencing at station B at High Water.

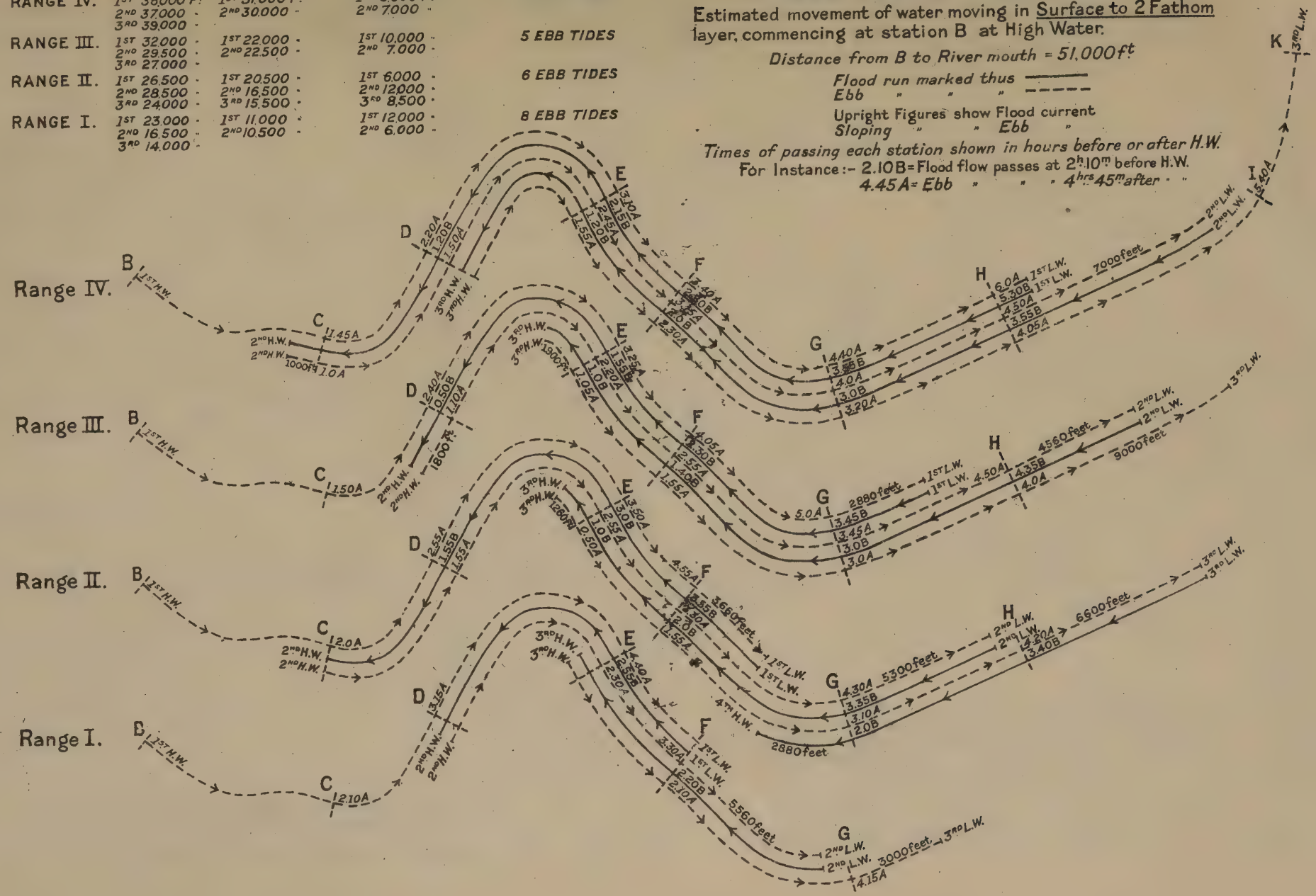
Distance from B to River mouth = 51,000 ft

Flood run marked thus ——
Ebb " " " - - - -

Upright Figures show Flood current
Sloping " " Ebb "

Times of passing each station shown in hours before or after H.W.
For Instance:- 2.10B = Flood flow passes at $2^h.10^m$ before H.W.
4.45A = Ebb " " " $4^{hrs}45^m$ after " "

	EBB RUN	FLOOD RUN	RESULTANT MOVEMENT 'DOWN' RIVER	TIME TAKEN TO REACH SEA
RANGE IV.	1ST 36,000 FT 2ND 37,000 " 3RD 39,000 "	1ST 31,000 FT 2ND 30,000 "	1ST 5,000 FT 2ND 7,000 "	3 EBB TIDES
RANGE III.	1ST 32,000 " 2ND 29,500 " 3RD 27,000 "	1ST 22,000 " 2ND 22,500 "	1ST 10,000 " 2ND 7,000 "	5 EBB TIDES
RANGE II.	1ST 26,500 " 2ND 28,500 " 3RD 24,000 "	1ST 20,500 " 2ND 16,500 " 3RD 15,500 "	1ST 6,000 " 2ND 12,000 " 3RD 8,500 "	6 EBB TIDES
RANGE I.	1ST 23,000 " 2ND 16,500 " 3RD 14,000 "	1ST 11,000 " 2ND 10,500 "	1ST 12,000 " 2ND 6,000 "	8 EBB TIDES



RIVER TEES SURVEY 1929

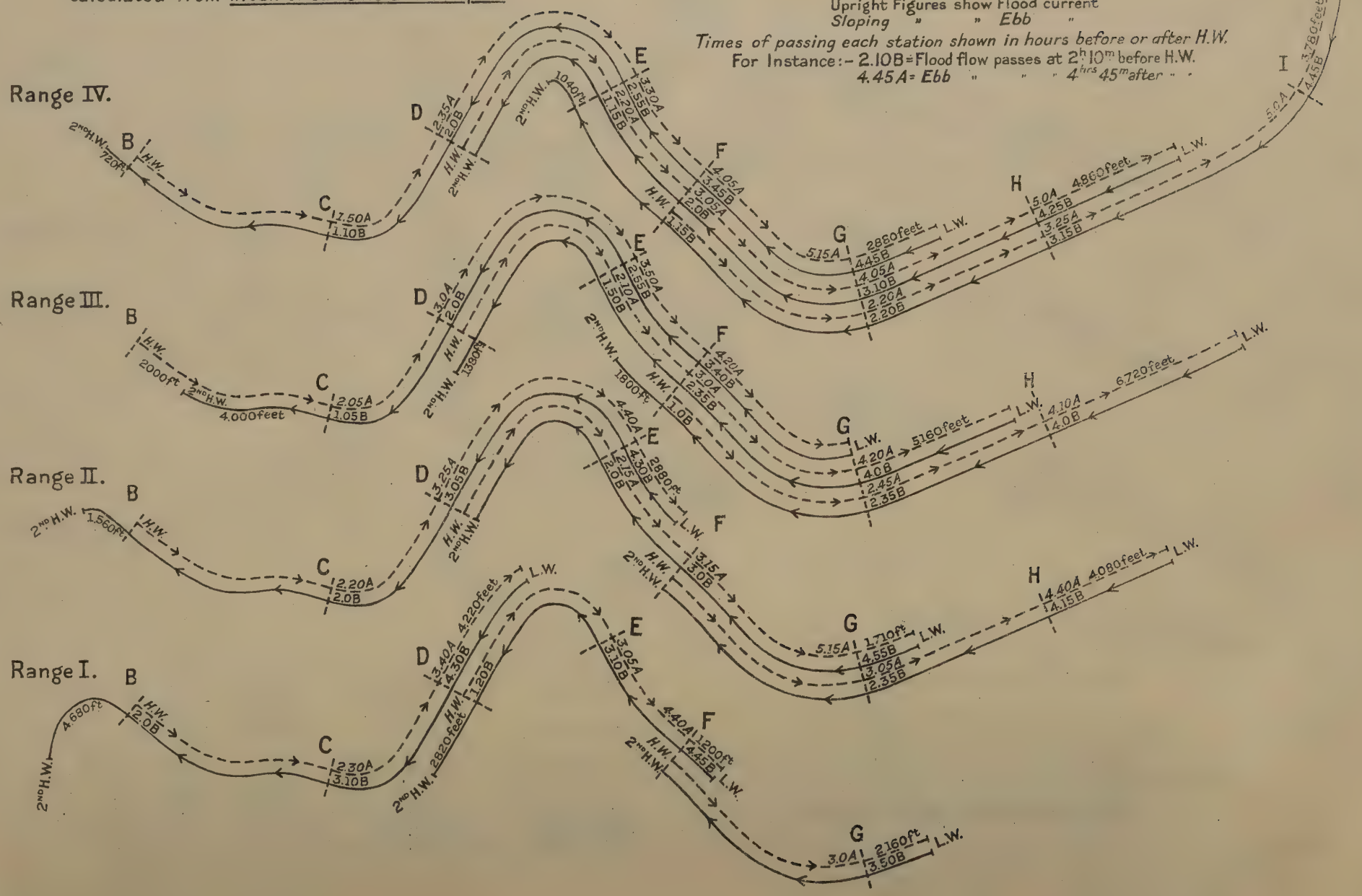
Diagram showing estimated water movement calculated from Mean of currents at all depths.

Distance from B to River mouth = 51,000ft

Flood run marked thus ——
Ebb " " " - - - -

Upright Figures show Flood current
Sloping " " Ebb "

Times of passing each station shown in hours before or after H.W.
For Instance:- 2.10B = Flood flow passes at $2^h 10^m$ before H.W.
4.45A = Ebb " " " 4^{hrs} 45^m after " "



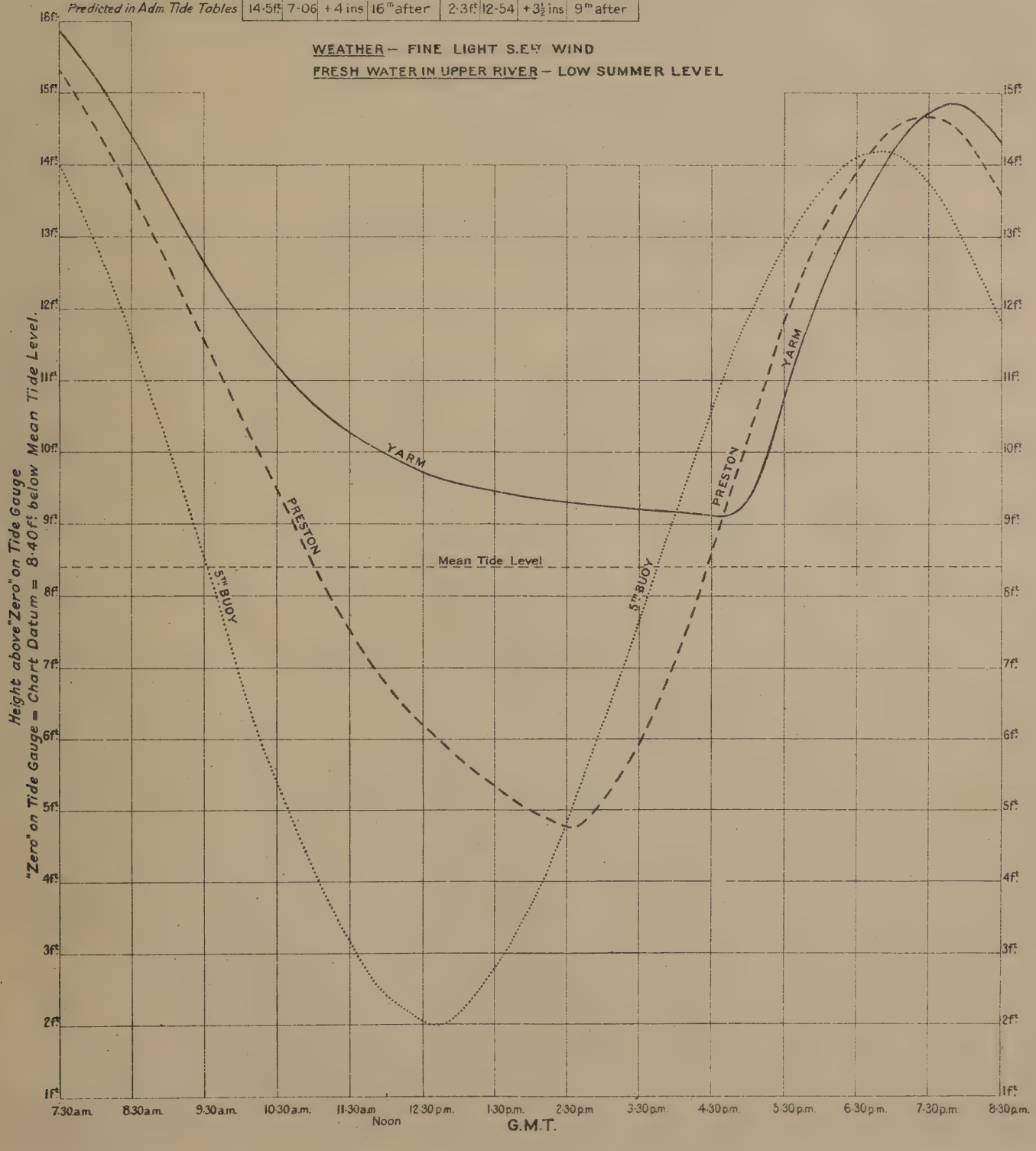
RIVER TEES SURVEY

PLATE 41

TIDE GAUGE OBSERVATIONS. 26TH JULY 1929. From 7-30 a.m. G.M.T. to 8-30 p.m. G.M.T.

	H.W.				L.W.			
			Interval from 5th Buoy				Interval from 5th Buoy	
	Height	Time p.m.	Height	Time	Height	Time p.m.	Height	Time
GOVERNMENT JETTY	14'-3"	6-50	+1 ins	Nil	2'-2"	12-50	+2 ins	5m after
5TH BUOY	14'-2"	6-50	—	—	2'-0"	12-45	—	—
10TH GAS BUOY	14'-4"	6-50	+2 ins	Nil	2'-0"	12-50	Nil	5m after
CARGO FLEET (Graving Dock)	14'-3"	6-50	+1 ins.	Nil	1'-11"	12-45	−1 ins	Nil
FURNESS SHIP-YARD	14'-5"	6-55	+3 ins	5m after	1'-11"	12-45	−1 ins	Nil
NEWPORT FERRY	14'-6"	7-00	+4 ins	10m after	1'-10"	12-45	−2 ins	Nil
STOCKTON (Corporation Quay)	14'-8"	6-50	+6 ins	Nil	1'-11"	12-50	−1 ins	5m after
PRESTON	14'-8"	7-25	+6 ins	35m after	4'-9"	2-40	+2'-9"	1hr 55m after
YARM	14'-10"	7-50	+8 ins	1hr after	9'-1"	4-40	+7'-1"	3hr 55m after
Predicted in Adm. Tide Tables	14-5ft	7-06	+4 ins	16m after	2-3ft	12-54	+3½ ins	9m after

Range of Tide predicted in Adm. Tide Tables ..... 12·9ft
Range observed at 5th Buoy ..... 12'-2"
do do do Stockton ..... 12'-9"
do do do Preston ..... 9'-11"
do do do Yarm ..... 5'-9"
H.W. (a.m.) observed at 5th Buoy 6·20 a.m. Height 15'-2"
do do predicted in Adm. Tide Tables 6·24 a.m. Height 15·2ft



RIVER TEES SURVEY

PLATE 42.

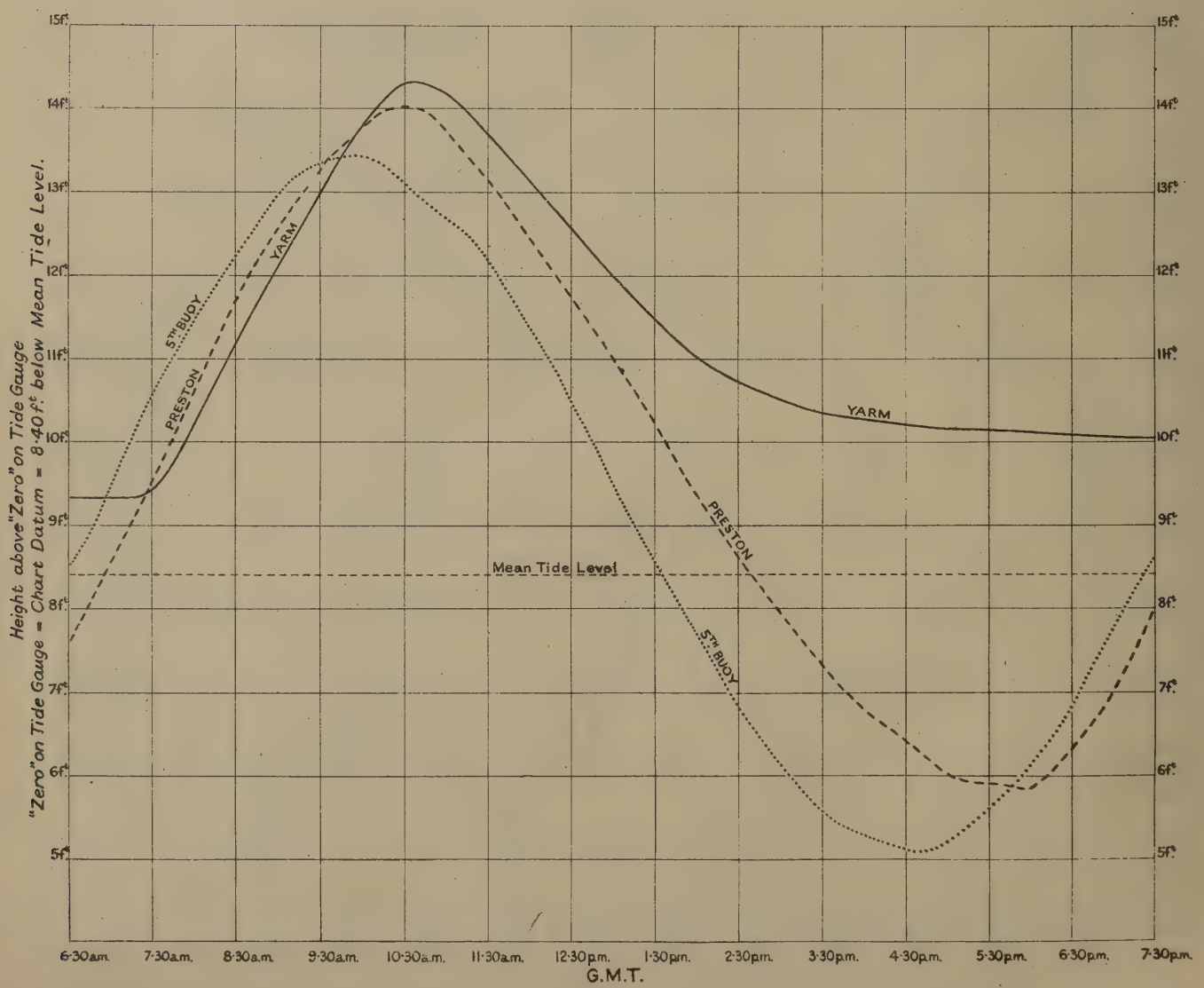
TIDE GAUGE OBSERVATIONS. 29TH AUGUST 1929. From 6-30 a.m. G.M.T. to 7-30 p.m. G.M.T.

	H.W.				L.W.			
			Interval from 5th Buoy				Interval from 5th Buoy	
	Height	Time	Height	Time	Height	Time	Height	Time
		a.m.				p.m.		
GOVERNMENT JETTY	13'-8"	9-55	+ 3 ins.	Nil	5'-2"	4-20	+ 1 ins.	20m before
5TH BUOY	13'-5"	9-55	–	–	5'-1"	4-40	–	–
10TH GAS BUOY	13'-5"	9-55	Nil	Nil	5'-1"	4-40	Nil	Nil
CARGO FLEET (Graving Dock)	13'-6"	9-55	+ 1 ins.	Nil	5'-1"	4-40	Nil	Nil
FURNESS SHIP-YARD	13'-7"	9-55	+ 2 ins.	Nil	5'-2"	4-40	+ 1 in.	Nil
NEWPORT FERRY	13'-8"	10-0	+ 3 ins.	5m after	5'-1"	4-40	Nil	Nil
STOCKTON (Corporation Quay)	13'-10"	10-0	+ 5 ins.	5m after	5'-1"	4-25	Nil	15m before
PRESTON	14'-0"	10-30	+ 7 ins.	35m after	5'-10"	5-55	+ 9 ins.	1½ hrs after
YARM	14'-4"	10-35	+ 11 ins.	40m after	10'-0"	8-30	+ 4ft. 11 ins.	4 hrs after
Predicted in Adm. Tide Tables	13·3ft.	10-06	– 2 ins.	11m after	4·9ft.	4-41	– 4 ins.	1m after

Range of Tide predicted in Adm. Tide Tables ..... 8'-6"
Range observed at 5th Buoy ..... 8'-4"
do do do Stockton ..... 8'-9"
do do do Preston ..... 8'-2"
do do do Yarm ..... 4'-4"

WEATHER – FINE, LIGHT TO FRESH S.W.LY WIND, CLOUDY

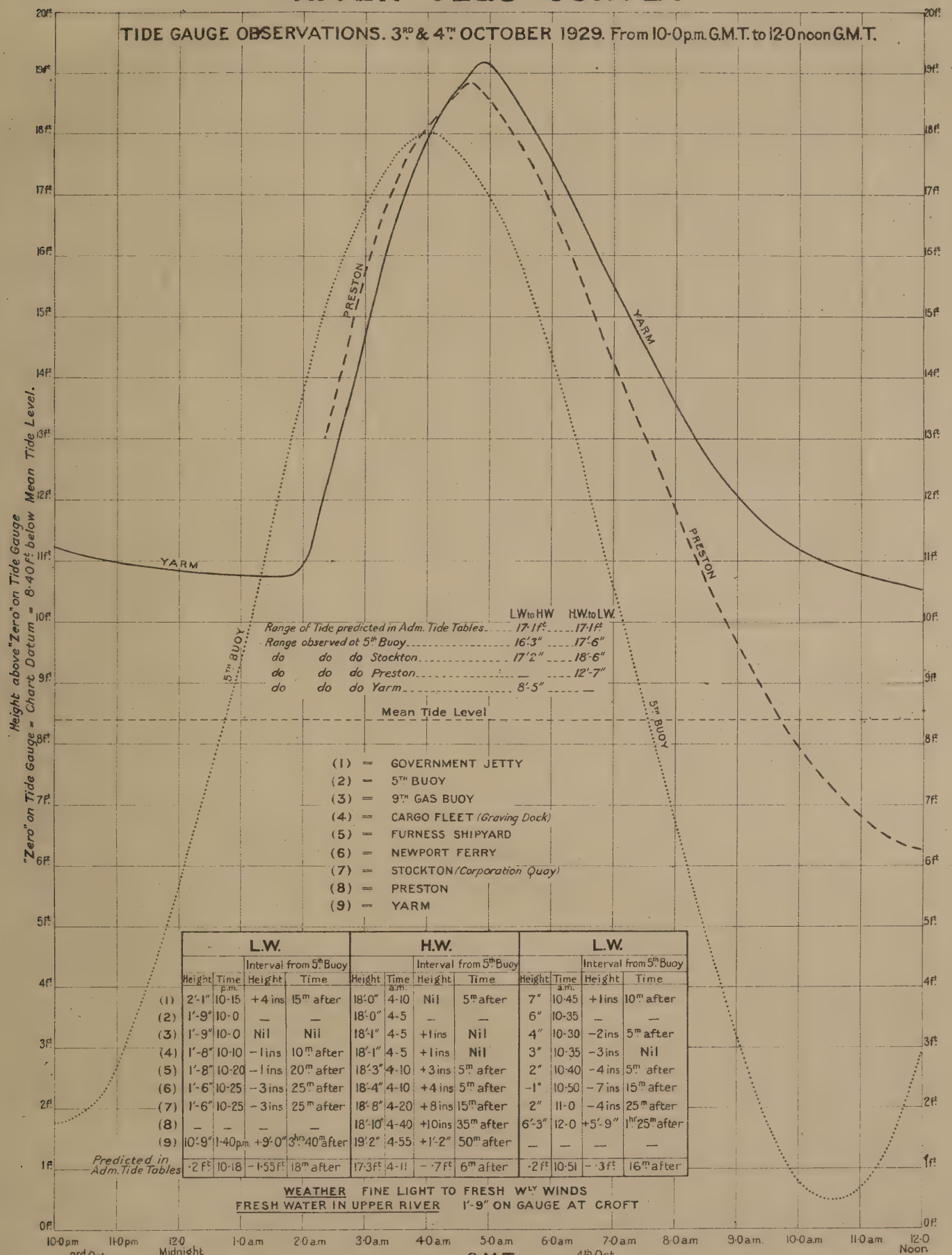
FRESH WATER IN UPPER RIVER – 1'-3" ON GAUGE AT CROFT



RIVER TEES SURVEY

PLATE 43

TIDE GAUGE OBSERVATIONS. 3RD & 4TH OCTOBER 1929. From 10-0p.m. G.M.T. to 12-0 noon G.M.T.



	LW to HW	HW to LW
Range of Tide predicted in Adm. Tide Tables	17·1ft.	17·1ft.
Range observed at 5th Buoy	16'3"	17'6"
do do do Stockton	17'2"	18'6"
do do do Preston	—	12'7"
do do do Yarm	8'5"	—

(1) = GOVERNMENT JETTY
(2) = 5TH BUOY
(3) = 9TH GAS BUOY
(4) = CARGO FLEET *(Graving Dock)*
(5) = FURNESS SHIPYARD
(6) = NEWPORT FERRY
(7) = STOCKTON *(Corporation Quay)*
(8) = PRESTON
(9) = YARM

	L.W.				H.W.				L.W.			
			Interval from 5th Buoy				Interval from 5th Buoy				Interval from 5th Buoy	
	Height	Time p.m.	Height	Time	Height	Time a.m.	Height	Time	Height	Time a.m.	Height	Time
(1)	2'-1"	10-15	+4 ins	15m after	18'-0"	4-10	Nil	5m after	7"	10-45	+1 ins	10m after
(2)	1'-9"	10-0	—	—	18'-0"	4-5	—	—	6"	10-35	—	—
(3)	1'-9"	10-0	Nil	Nil	18'-1"	4-5	+1 ins	Nil	4"	10-30	−2 ins	5m after
(4)	1'-8"	10-10	−1 ins	10m after	18'-1"	4-5	+1 ins	Nil	3"	10-35	−3 ins	Nil
(5)	1'-8"	10-20	−1 ins	20m after	18'-3"	4-10	+3 ins	5m after	2"	10-40	−4 ins	5m after
(6)	1'-6"	10-25	−3 ins	25m after	18'-4"	4-10	+4 ins	5m after	−1"	10-50	−7 ins	15m after
(7)	1'-6"	10-25	−3 ins	25m after	18'-8"	4-20	+8 ins	15m after	2"	11-0	−4 ins	25m after
(8)	—	—	—	—	18'-10"	4-40	+10 ins	35m after	6'-3"	12-0	+5'-9"	1hr 25m after
(9)	10'-9"	1-40p.m.	+9'-0"	3hrs 40m after	19'-2"	4-55	+1'-2"	50m after	—	—	—	—
Predicted in Adm. Tide Tables	·2 ft	10-18	−1·55 ft	18m after	17·3 ft	4-11	−·7 ft	6m after	·2 ft	10-51	−·3 ft	16m after

WEATHER FINE LIGHT TO FRESH WLY WINDS
FRESH WATER IN UPPER RIVER 1'-9" ON GAUGE AT CROFT

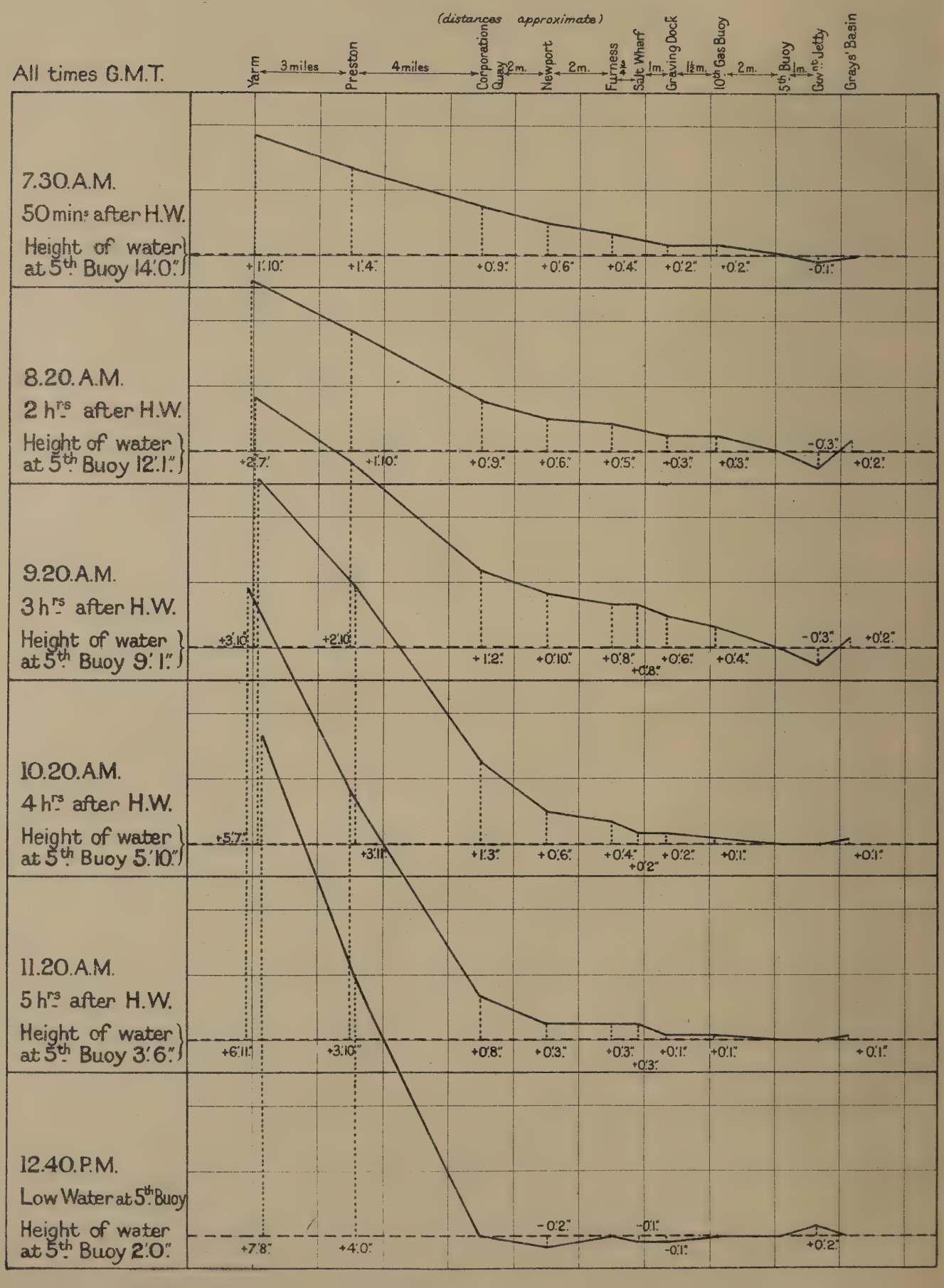
RIVER TEES SURVEY 1929

Tide Gauge Observations 26-7-29 Range of Tide 12 ft.

Table showing water levels at intervals of 1 hour, from 1 hour after High Water at 5th Buoy 26-7-29 (A.M.) until High Water (P.M.) at 5th Buoy on the same day.

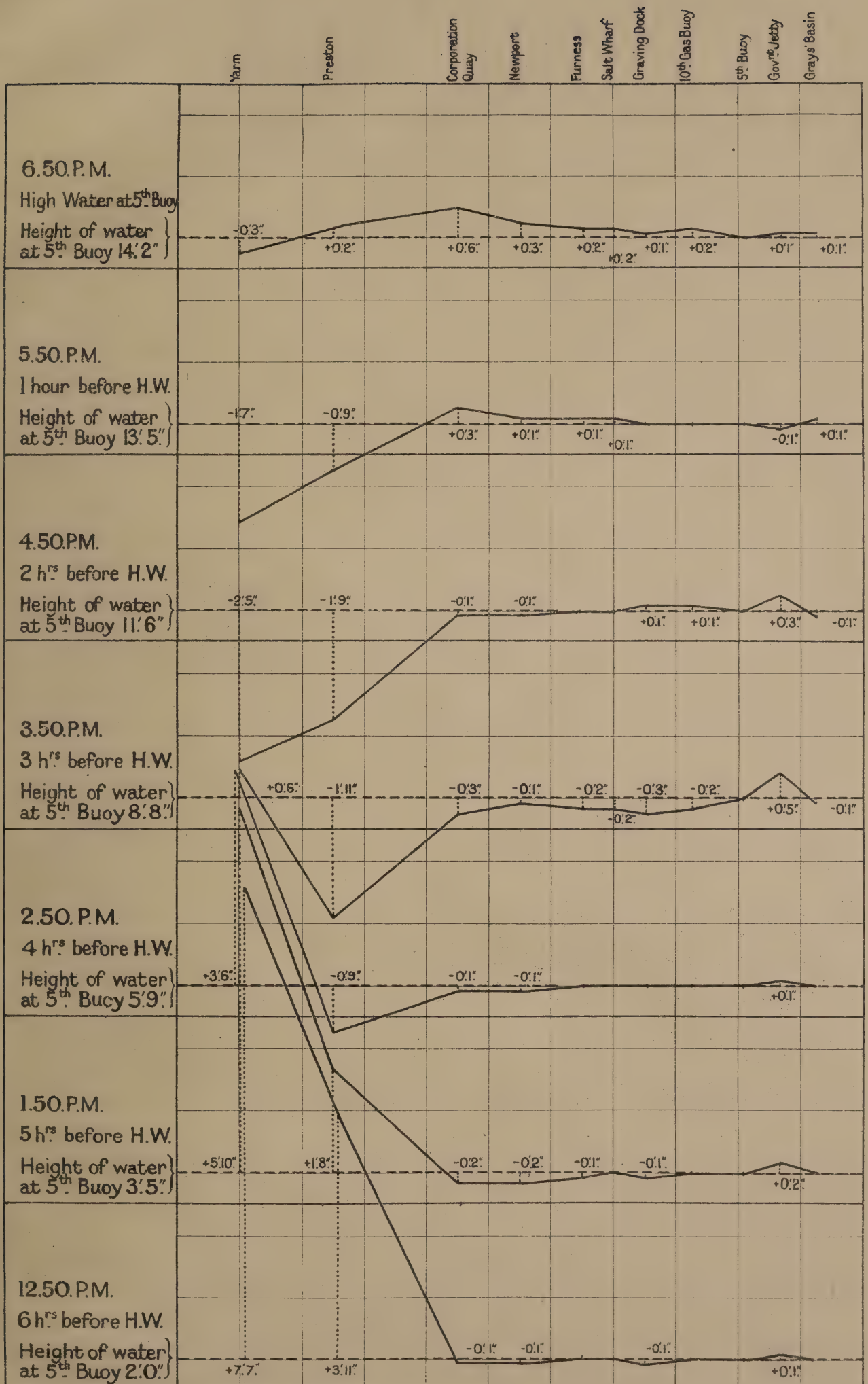
All differences of levels refer (plus or minus) to water level at 5th Buoy.

Pecked line shows water level at 5th Buoy.



Vertical Scale

Inches 12 6 0 1 2 3 4 5 6 7 Feet



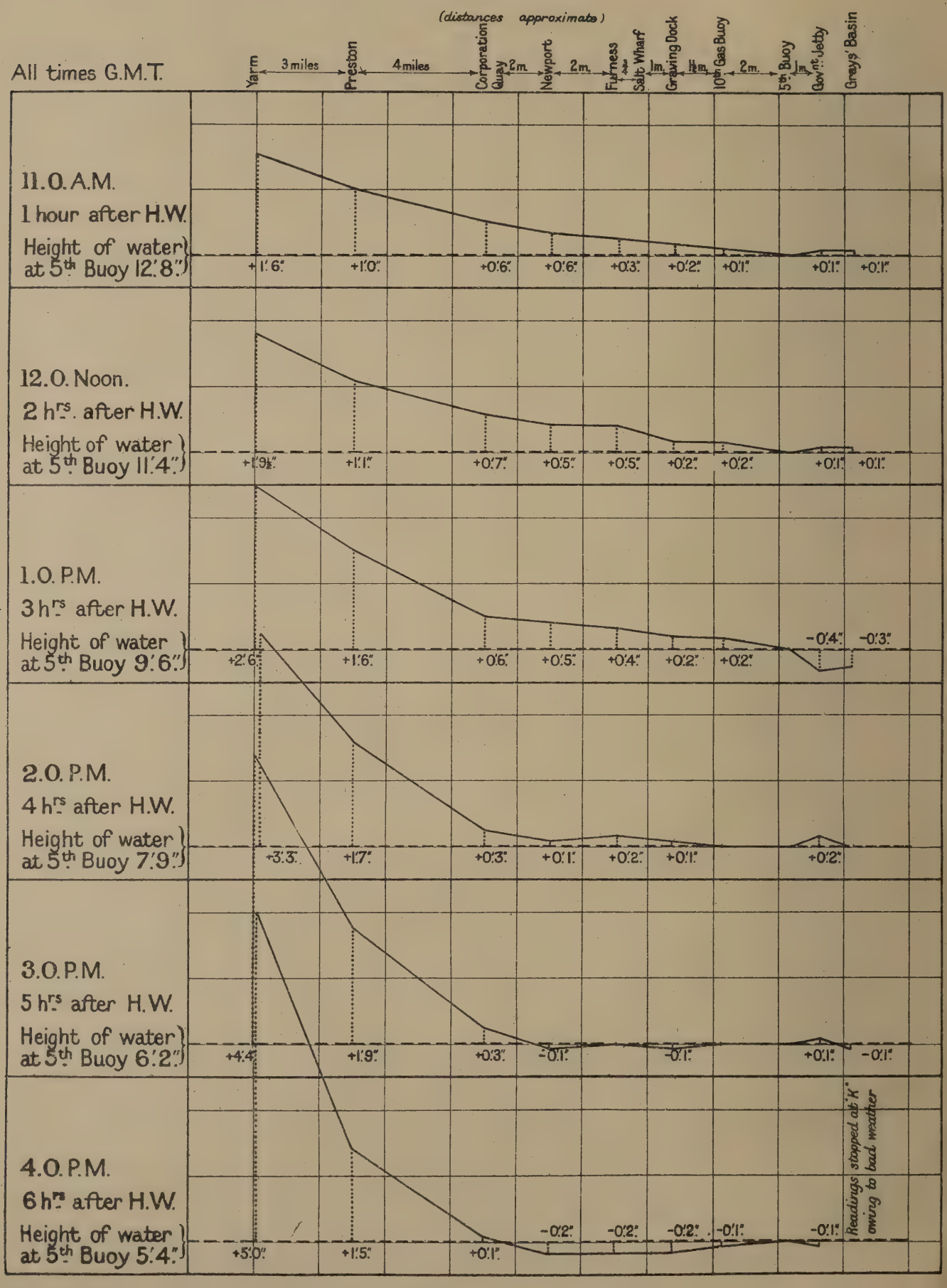
Weather—Fine. Light S.E.ly wind. Little or no rain during previous 7 days.
Fresh water in upper river at "Low Summer Level"

RIVER TEES SURVEY 1929

Tide Gauge Observations 29-8-29 Range of Tide 8'.6"

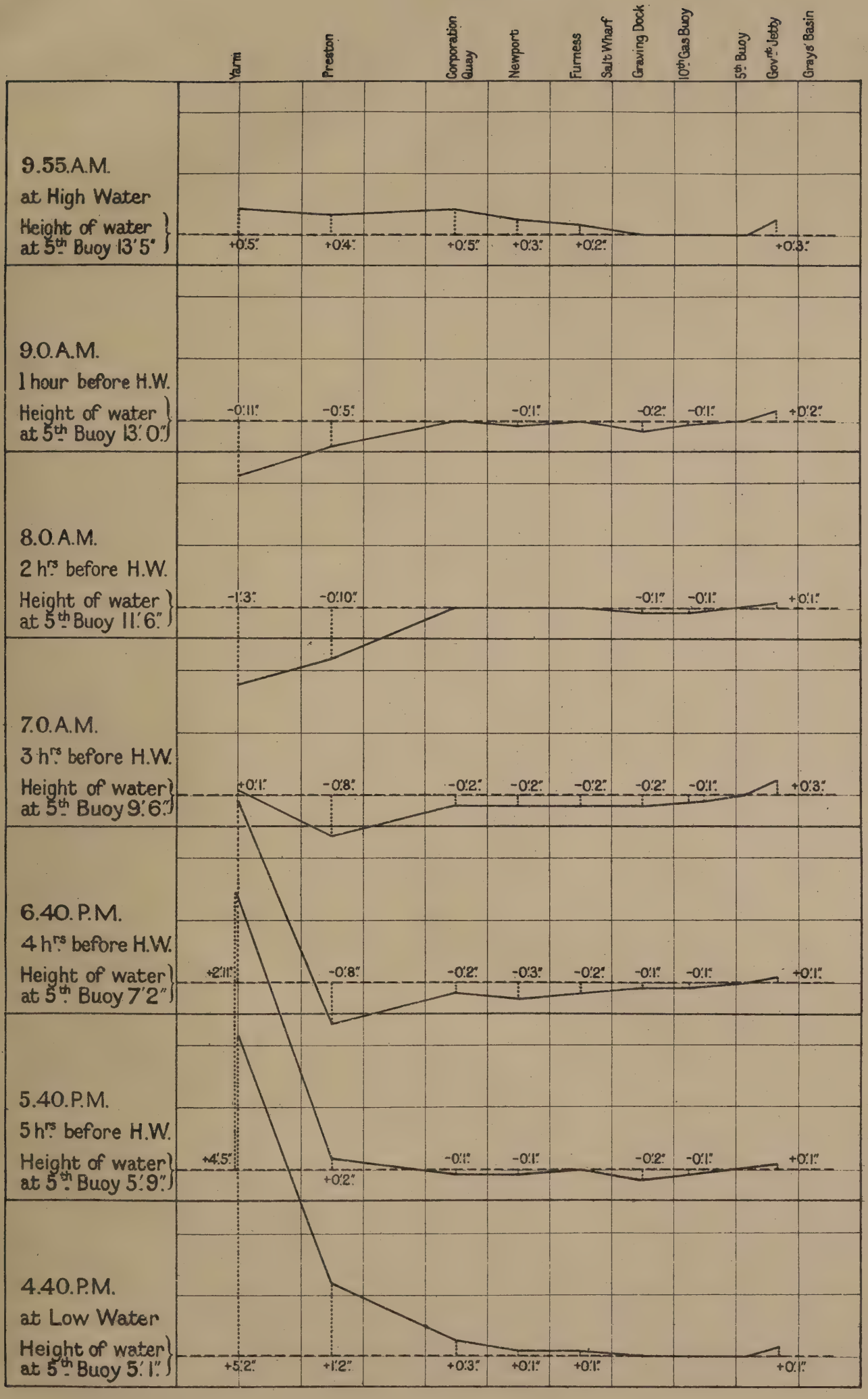
Table showing water levels at intervals of 1 hour, from 1 hour after High Water until next High Water.
All differences of level refer (plus or minus) to water level at 5th Buoy.

Pecked line shows water level at 5th Buoy



Vertical Scale

Inches 12 6 0 1' 2 3 4 5 6 7 Feet



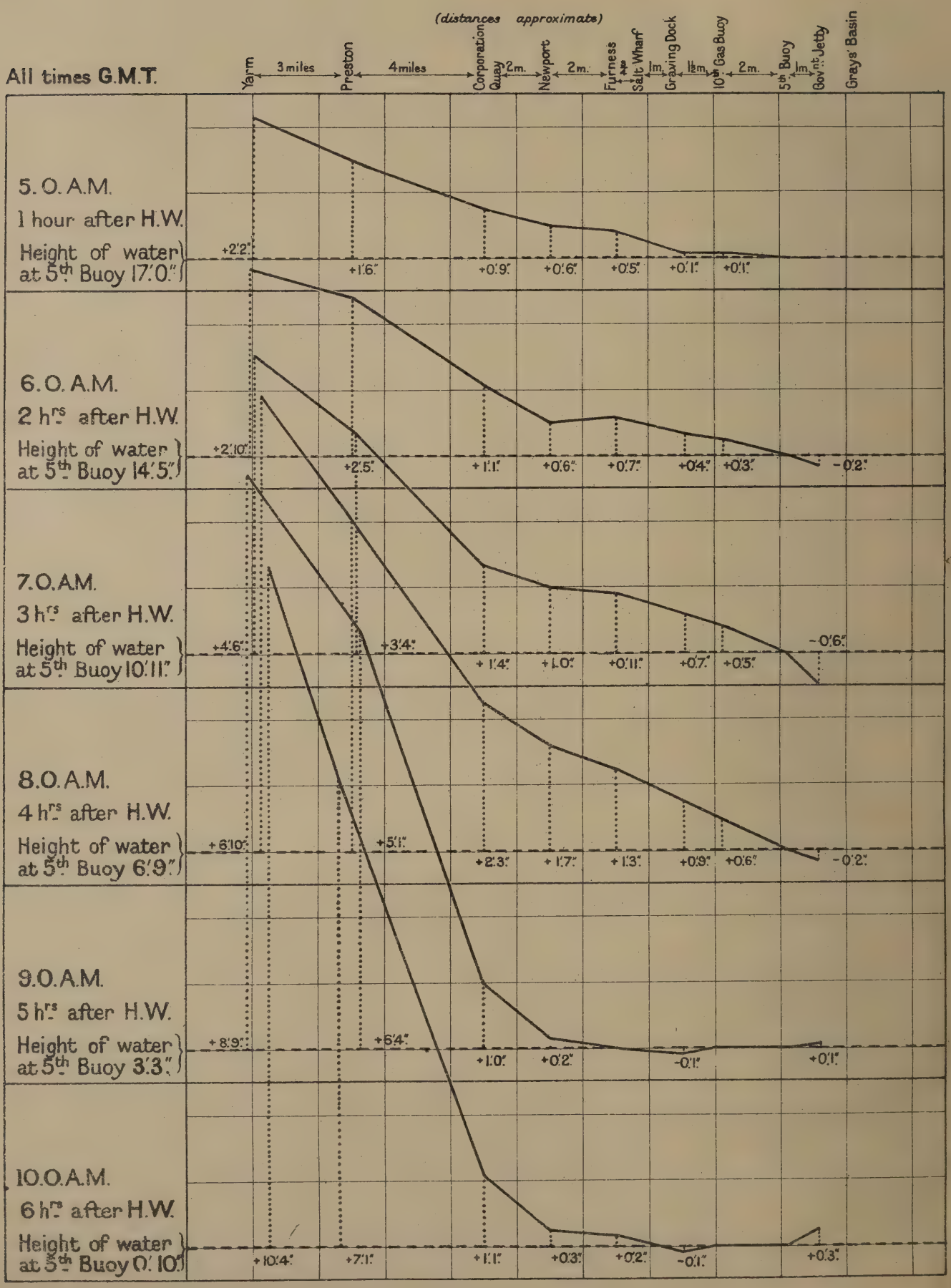
Weather — Fine, Light to Fresh S.W.ly Winds. Cloudy.
Fresh water in upper river 1'3" on gauge at Croft.

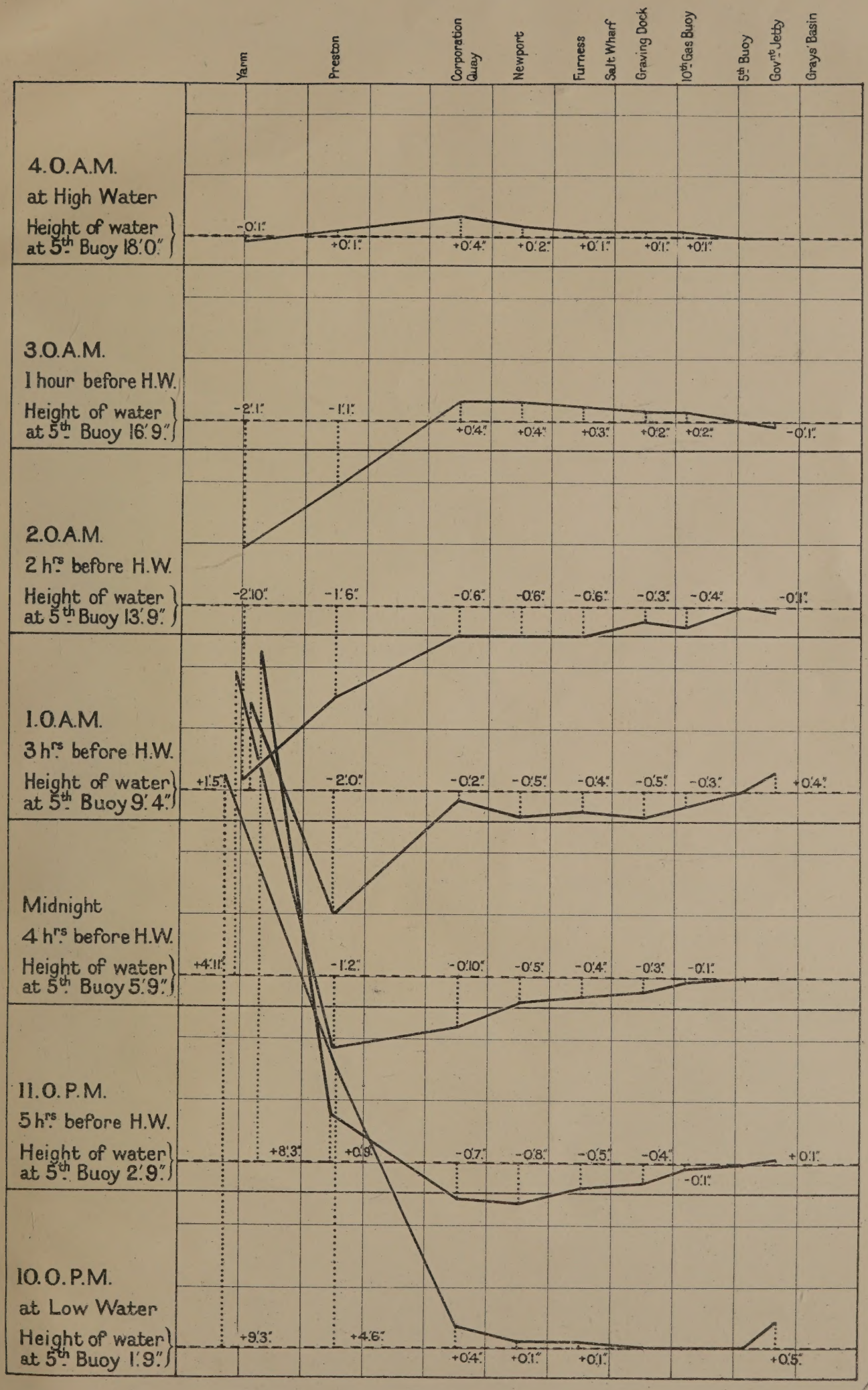
RIVER TEES SURVEY 1929

Tide Gauge Observations 3rd & 4th Oct. 1929. Range of Tide 17'.0"

Table showing water levels at intervals of 1 hour, from 1 hour after High Water 5th Buoy until High Wate
All differences of levels refer (plus or minus) to water level at 5th Buoy.

Pecked line shows water level at 5th Buoy.





Weather — Fine, Light to Fresh Westerly Winds.

Fresh water in upper river 1'.9" above zero on gauge at Croft.

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